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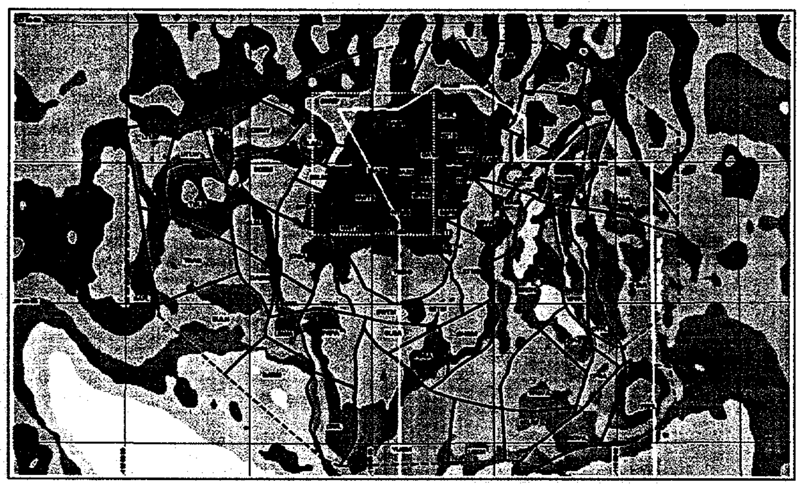

Purpose and Scope

To model the regional flow of groundwater within the southwestern Nevada volcanic field (SWNVF) of the Nevada Test Site (NTS), the subsurface geology must be described completely, even within regions where confidence in geologic interpretation is low. This report provides a two-dimensional representation of geologic structures that we consider the most significant within the SWNVF. Included are obvious, well known structures related to Basin-Range faulting or caldera formation, as well as buried, conjectural structures that explain discontinuities in mapped geologic units and/or distinctive features in regional geophysical datasets. The intersection of these structures forms a veritable jigsaw puzzle of structural blocks. Within each block, stratigraphic units are relatively uniform in character, and each block has a unique structural history that differs from that of its neighbors. The three-dimensional geology can be accurately constructed when subsurface and geophysical data are both available, or crudely conceptualized from geologic maps and geophysical data alone if drill holes have not been sited within the block. We provide a three-dimensional representation for an area centered on the Western Area 20 structural block. For all other blocks, we provide a summary of important structural data to guide construction of a three dimensional representation. Finally, to apply our three-dimensional geologic model for hydrologic modeling, stratigraphic units must be assembled, subdivided, or modeled as hydrogeologic units. We provide tables that allow conversion of this geologic model into a hydrogeologic model.

A two-dimensional structural model for the SWNVF based on linear structural elements

The most obvious geologic features of the SWNVF are calderas formed by the voluminous eruptions of zoned ignimbrites between 16 and 7.5 Ma ago. Most regional descriptions of the SWNVF assume that these calderas have approximately circular boundaries (Sawyer et al., 1994; Noble et al., 1991; Christiansen et al., 1977; Byers et al., 1976a and b), although structural boundaries of all calderas are obscured by burial or later resurgence. The location of even the largest and youngest calderas is only generally known, so the geometry of their structural boundaries can only be reckoned. In contrast, locations are well known for contemporaneous Basin-Range faults, which were clearly coupled with caldera formation (Warren et al., 1985; Christiansen et al., 1977; Cummings, 1968). Seismic refraction surveys found an exact correspondence between two Basin-Range faults and deeply buried boundaries for the Area 20 and Grouse Canyon calderas (Ferguson et al., 1994). Considering this finding and the highly extensional nature of the Basin-Range province, Ferguson et al. (1994) consider the creation of circular calderas unlikely within the SWNVF. In the words of Kane et al. (1981): "...gravity and aeromagnetic surveys of the Timber Mountain region ... have revealed new details of subsurface structure and lithology. The data strongly suggest that deformation caused by volcanic events has been accommodated along straight-line faults combining in such a fashion as to give a curvilinear appearance to the regional structure. Some of the curvilinear aspect may be caused by erosion and perhaps surface slumping following formation of the caldera."

Drilling for nuclear testing has provided extensive geologic data for subsurface of Pahute Mesa that demonstrates a unique episodic history of activity for each of the Basin-Range faults within this region of the SWNVF (Warren et al., 1985). These data demonstrate that the West Greeley fault has the greatest displacement of units that filled or buried the 13.1 Ma Area 20 and 13.6 Ma Grouse Canyon calderas formed there. The maximum cumulative displacement across this structure for the top of the 12.9 Ma Calico Hills formation is approximately 500 m (see data in Warren et al., 2000), compared with about 250 m displacement for the top of 11.6 Ma Rainier Mesa Tuff (Prothro and Warren, 2000). Clearly, faults of such magnitude have important hydrologic effects, and effectively bound blocks that generally differ appreciably from neighboring blocks in their stratigraphic constitution. In other regions where subsurface geologic data are unavailable or sparse, representations of regional geophysical data such as gravity (Hildenbrand et al., 1999; McKee et al., 1999; Mankinen et al., 1999) or magnetic intensities (Grauch et al., 1999; Mankinen et al., 1999) usually reveal master faults.

More than 70 structural blocks have been defined for the SWNVF in Table 1, using a linear structural model on the accompanying map. The blocks are based on known or suspected caldera locations (Sawyer et al., 1994; Ferguson et al., 1994; Noble et al., 1991; Carr et al., 1986; Byers et al., 1976a and b; Sargent and Orkild, 1973; Orkild et al., 1969), Basin-Range structural elements (Prothro and Warren, 2000; Warren et al., 1985; Byers et al., 1976b; Sargent and Orkild, 1973; Orkild et al., 1969), regional geologic and geophysical datasets (Hildenbrand et al., 1999; McKee et al., 1999; Grauch et al., 1999; Wahl et al., 1997; Sawyer et al., 1995; Minor et al., 1993) and structural data within the *geol_int* table of the petrographic/geochemical database for the SWNVF (Warren et al., 2000). Block boundaries frequently correspond with steep gradients within the regional gravity field, as seen in Figure 1. Where available, data from subsurface demonstrate that there are no major fault displacements within blocks of Pahute Mesa. Each block generally consists of tilted, tapering sequences of stratigraphic units, as illustrated in Figure 2, with each sequence identified as *intra-, near-, or extra- caldera,* as described below. Stratigraphic (and hydrogeologic) units within the SWNVF are generally tilted and tapered due to 1) rotation along both orthogonal sets of major structures within the SWNVF, 2) a prevalent asymmetry (trap-door style) for calderas, 3) proximity to an eruptive source, 4) deposition into the eroded edge of a structurally high block, and 5) deposition onto a tilted structural block. Tilting generally occurs concurrently along two orthogonal horizontal axes, each axis parallel to the orthogonal structures shown

Table 1. Descriptions for structural blocks of the SWNVF

Symbols for stratigraphic units are defined in Table 2, and in parentheses for hydrogeologic unit type in Table 6. Structural descriptions refer to general elevations above Mean Sea Level for the top of the unit being described: structurally very high = >1500 m; structurally high = 1000 to 1500 m; structurally intermediate = 0 to 1000 m; structurally low = <0 m. *TD* is elevation at bottom of hole.

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Saucer Mesa	SAUM	The block is structurally very high, north of the Grouse Canyon caldera (Ferguson et al., 1994), with Tbd and Tbg both wedging out at the northern edge of the block (Orkild et al., 1969;.Wahl et al., 1997). Tbd thickens to about 400 m near the caldera rim at the southern end of the block. Tbg thins toward the caldera from a medial maximum thickness in the block, like Tm relative to the Timber Mountain caldera complex (Warren et al., 1985). Older rocks probably thicken towards the Grouse Canyon caldera, considering the gravity (Figure 1), which indicates a southward dip for the pre-Tertiary surface.	557.1	4137.3	Tbd (LF) >2200, Tbg (EW) 1900, Tu (LF?) 1750?
			557.8	4146.7	Tbg (EW) 1920, Tq (EN) 1770, Tk (LF) 1600?, pre-T 1400??
Southern Kawich Valley	SKAV	Structurally low. Thickness of alluvium and volcanics unknown.	569.1	4137.8	Tm (EW) 1500??, Tbd (LF), Tbg (EW), Tu (LF), Tot? (EW), Tk (LF)
Central Belted Range	CBER	Tk is structurally very high.	579.8	4142	Tub (EW) 2400, Tk (TC) 2350, Te (EW) <1500
Southern Belted Range	SBER	Post-Tub lavas, Tub structurally much lower than block to N. Possibly intracaldera Tub. Tbt map unit of Sargent and Orkild (1973) is not Tub, but Tbq.	577.3	4134.9	Tbq (LF) >2200, Tbg (EW) 2040, Tuo (LF) 1920, Tub (EW?) 1700??
Southeastern Belted Range	SEBR	Structurally high Tm through Tu.	584.7	4132.4	Tm (EW) 1770, Th/Tc (EN) 1650, Tbg (EW) 1550, Tu (LF) 1450
Emigrant Valley	EMIV	A deep gravity low (Figure 1) indicates a structurally low basin. Elevations for the pre-Tertiary surface (Barnes et al., 1965) indicate that this block is north-plunging. Relatively thick volcanics are probably ponded within this basin, as Grouse Canyon Tuff and older units are thickly accumulated within erosional or structural topographic depressions within adjacent blocks to the west.	599.6	4128.8	
Northern Halfpint Range	NHAR	Structurally very high pC and lower Paleozoic draped with thin volcanics, with the pre-Tertiary surface slightly lower than in the Oak Spring Butte block to the west. Elevations for the pre-Tertiary surface are provided by Barnes et al. (1965 and 1963).	593.6	4112.6	Tub (EW) 1730, To (EN) 1700, Te (EW) 1600, pre-T 1550

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM) E	Location (km UTM) N	Strat, hydrogeol, top elev (m) at location
Oak Spring Butte	OASB	Structurally very high, with outcrops primarily lower Paleozoic, intruded by Cretaceous plutonics (Sargent and Orkild, 1973). Tb and older units thicken to the east in a narrow band near the central part of the block, certainly above a deep paleovalley.	583.9	4122.4	
Quartzite Ridge	QUAR	Structurally very high, with pre-Tertiary outcrops primarily upper Paleozoic, with a thin mantle of Tb and older units (Sargent and Orkild, 1973), certainly deposited within a deep paleovalley.	577.2	4119.6	Tm (EW) 2070, Th/Tc (EN) 1980, Tbg (EW) 1920, To (EN) 1900, pre-T 1700
Aqueduct Mesa	AQME	Strongly tilted block, structurally high to SE, where pre-Tertiary crops out, and intermediate to NE. Stratigraphic data from UE12P2 (Miller, 1970) and from UE12P4 (Warren et al., 2000) in this table, combined with data from outcrop (Sargent and Orkild, 1973; Sargent et al., 1966), require that the volcanic sequence steepen markedly to the northeast above a NE-plunging pre-Tertiary surface that is exposed in the southern part of the block. A relatively narrow gravity high along the western side of the block indicates that the pre-Tertiary is structurally high there. The prevalent SE dips in the volcanics probably flatten and slightly reverse direction in the eastern part of the block, following attitudes and fold axes in Tmr, exposed at the surface there.	574.2	4121	Tm (EW) 1950, Th (EN) 1745, Tw (EN) 1712, Tc (EN) 1704, Tbg (EW) 1580, Tbgb/Tn (EN) 1530, pre-T 1410
Kawich Canyon	KAWC	Extracaldera block east of Grouse Canyon caldera with intermediate Tbd thickness and thin Tbg. Tbd and Tbg crop out successively to the north in this block (Sargent and Orkild, 1973; Wahl et al., 1997), indicating Tb at relatively high structural levels within this block, and that the pre-Tertiary surface dips southward. Isostatic gravity signature (Figure 1) is similar to that of the Big Burn Valley block adjacent to the south, which has an elevation of 1.0 km for its pre-Tertiary surface (Figure 10 in Ferguson et al., 1994).	566.7	4125.6	Tm (EW) 2250, Th/Tc (EN) 2220, Tbd (LF) 2130, Tbg (EW) 1650?
Eastern Area 19	EA19	This block, outside Area 20 caldera, lies within outer (late) collapse zone of the Grouse Canyon caldera. Thin extracaldera Tbg has dropped to low structural levels during late (post-Tbg) collapse of the Grouse Canyon caldera, and filling of this outer collapse zone with very thick Tbd (Ferguson et al., 1994). Structural levels, represented in this table by UE19C (Warren et al., 2000), are substantially higher in the adjacent Central Area 19 block, constrained by UE19I (Warren et al., 2000). Thus the Eastern Area 19 block must be tilted northward.	560.3	4124.7	Tm (EW) 2150, Tp (EW) 1679, Th/Tc (TC) 1632, Tbd (LF) 1419, Tbg (LF) -106, Tbq (TC) -182, TD -444
Dead Horse Flat	DHFL	Thin Tcbl, thick Tbd, and intermediate Tbg within the outer collapse zone of the Grouse Canyon caldera (Ferguson et al., 1994), represented in this table by U19D2 (Warren et al., 2000).	560.1	4133.5	Tm (EW) 2100, Th/Tc (TC) 1988, Tbd (LF) 1917, Tbg (LF) 685, Tr/Tbq (TC) 364, TD -252

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM) E	Location (km UTM) N	Strat, hydrogeol, top elev (m) at location
Southeastern Gold Flat	SEGF	A deep gravity low (Figure 1) indicates a structurally low basin. Elevation layers for the 3-D geologic model of this report show thin deposits for all units of the Tc Group and younger, suggesting the presence of moderately thick QTa.	549.9	4143.9	
Northcentral Area 19	NC19	Intermediate Tcbl, thick Tbd, thick Tbg within the inner collapse zone of the Grouse Canyon caldera, represented in this table by UE19G\S and UE19E (Warren et al., 2000).	556.3	4129.1	Tm (EW) 2048, Th/Tc (TC) 1466, Tcbl (EN) 1389, Tbd (LF) 1240, Tbg (IW) 417, Tbq (TC) -159, TD -240
			559.1	4127.8	Tm (EW) 2109, Th/Tc (TC) 1582, Tcbl (EN) 1489, Tbd (LF) 1215, Tbg (IW) 438, TD 278
Basalt Ridge	BASR	In UE20E1, thick Th/Tc fills the Area 20 half graben (Warren et al., 2000), a structural feature superimposed on the Area 20 caldera. But thin Tcbl is extracaldera within this block (Ferguson et al., 1994; Warren et al., 1985). Thick Tbd suggests that the Grouse Canyon caldera, perhaps the outer collapse zone, is probably within this block (Ferguson et al., 1994).	548.1	4130	Tt (EW) 1919, Tm (EW) 1814, Th/Tc (TC) 1495, Tbd (LF) 361, TD -30
Southwestern Gold Flat	SWGF	Structurally high Tm through Tbg with intermediate thicknesses below, through To, represented in this table by PM2 (Warren et al., 2000) and UE20J (Noto et al., 1999). Very thick caldera precursor lava of Tqm occurs in PM2, suggesting a proximal location to Tolicha Peak caldera there.	538.3	4133	Tt (EW) 1702, Tbg (EW) 1593, Tqt (EN) 1538, Tub (EN) 1404, Tqb (TC) 1300, To (EN) 1251, Tqm (LF) 983, TD -974
			541.3	4128	Tt (EW) 1799, Tm (EW) 1607, Tcbs (EW) 1269, Tbg (EW) 1226, Tub (EW) 1222, Tqb (TC) 807, To (EN) 421, TD 65

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Black Mtn	BLAM	The location of this block, which defines intracaldera Black Mtn caldera, must lie within the topographic boundary of the Post-Spearhead caldera shown by Noble and Christiansen (1968); the Spearhead Member has been renamed to the Pahute Mesa Tuff (Noble et al., 1984). Because this young caldera is known only from outcrop (Wahl et al., 1997; Noble and Christiansen, 1968) and has nowhere been exhumed by erosion, thicknesses and attitudes for all subsurface units within this block are conjectural.	531.3	4126.1	Tth (LF) 2200, Ttt (IW) <1740
South of Black Mountain	SBLM	This block has an isostatic gravity signature similar to that of the Northwestern Timber Mtn Bench, but is the locus for the Ribbon Cliff trough (Prothro and Warren, 2000), probably formed by eastward rotation of units against the Purse fault, the signature structural style of Pahute Mesa (Warren et al., 1985).	535.2	4119.3	
Ribbon Cliff	RBCF	This block is characterized by a single drill hole, PM3 (Warren et al., 2000), which shows structurally high to intermediate Tm through Tbg. Thicknesses and elevations down through the top of Th/Tc are similar to those in the Western Area 20 block adjacent to the east (Warren et al., 2000). These units are probably rotated eastward along the Purse fault. However, Th/Tc is very thin and clearly outside both the Area 20 caldera and Area 20 half graben of the adjacent Western Area 20 block. The pre-Tertiary surface is at about 1.0 km below sea level in the structurally similar Southwestern Gold Flat block, adjacent to the north (Figure 10 in Ferguson et al., 1994); because Tbg is lower in the Ribbon Cliff block, the pre-Tertiary surface is probably less than 1.0 km below sea level.	539	4121.3	Tt (EW) 1775, Tm (EW) 1621, Tp (EN) 1223, Th/Tcbs (EN) 952, Tbg (EW) 876, Tq (EN) 860, TD 855
Western Area 20	WA20	Structurally intermediate, Area 20 caldera-burying units of Tp and Th within this block dip northeast (Warren et al., 1985). Older units within this block are best characterized by UE20F (Noto et al., 1999), which penetrates thick, intracaldera Tcbl of the Area 20 caldera and thick overlying Th/Tc, which thins rapidly westward from the West Greeley fault within the Area 20 half graben (Ferguson et al., 1994; Warren et al., 1985). Tb below the floor of the Area 20 caldera includes thin extracaldera Tbg and intermediate Tbq, but the great thickness for To in UE20F suggests that an even older caldera might be located within the block. The pre-Tertiary surface is at about 2 km below sea level (Figure 10 in Ferguson et al., 1994).	545.4	4124.9	Tt (EW) 1864, Tm (EW) 1764, Tp (EW) 1111, Th/Tc (TC) 965, Tcbl (IN) 5, Tbd (LF) -657, Tbg(EN) -1110, Tbq (EW) -1147, To (EN) -1514, TD -2307
Eastern Area 20	EA20	Thick Th fills the Area 20 half graben, which deeply drops intracaldera Tcbl within the Area 20 caldera. This block is structurally much higher within Tp than the Western Area 20 block adjacent to the west, owing to pre-Typ episodic displacement along the West Boxcar fault (Warren et al., 1985), but otherwise is structurally similar. Data are best represented by U20I in the northern part of the block by U20WW to the top of Th, and in this table by UE20H to its TD in Tcbp (Noto et al., 1999). The pre-Tertiary surface is at about 2 km below sea level (Figure 10 in Ferguson et al., 1994).	550.2	4125	Tt (EW) 1999, Tm (EW) 1947, Th/Tc (TC) 1651, TD -198

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Northwestern Timber Mtn Bench	NWTB	ER/EC1 (IT Corporation, 2000b) and ER/EC6 (Bechtel Nevada, 2000), with stratigraphic assignments in this table for ER/EC6 modified from more recent unpublished work by R. G. Warren, demonstrate that this block lies outside the Ammonia Tanks and Rainier Mesa calderas, outside any calderas of Tp, and probably outside the Area 20 caldera. Mankinen et al. (1999) model relatively high isostatic gravity values to calculate a relatively thin section of volcanic rocks above a "basement ridge" within the eastern part of this block. This feature is contiguous into the adjacent Northern Timber Mtn Bench. Elevation layers for the 3-D geologic model of this report show that these two blocks have highly different structural character, so that similar thicknesses of volcanic rock are unlikely. Extreme alteration within ER/EC6 suggests that the gravity feature instead reflects relatively high densities localized by hydrothermal alteration along the Boxcar fault, which bounds the block on the east and bisects the gravity feature.	544.7	4115.7	Tmat (TC) 1708, Tmrf (EN) 1297, Tp (TC) 1248, Tpc (EW) 974, Tp (EN) 865, Tpt (EW) 795, Th (EN) 624, Tcps (TC) 501, TD 184
Northern Thirsty Canyon	NTCA	Thick Tt generally dips SE, and structurally intermediate Tm lies outside Rainier Mesa and Ammonia Tanks calderas, based on recent unpublished work by R. G. Warren for ER/EC4.	532.7	4112.5	Typ (LF) 1442, Tt (EW) 1426, Tt (LF) 1154, Tf (EN) 942, Tma (EW) 849, Tmr (EN) 530, TD 379
Tolicha Peak	TOLP	Structurally high, highly faulted block with generally older units towards the south, and thick Tqt dominating exposed units, extracaldera near source caldera, with an exposed thickness of >300 m and typical dips of 30-50° (Minor et al., 1998; Wahl et al., 1997; Hausback and Frizzell, unpublished geologic map of Tolicha Peak 7.5' quadrangle). The extreme faulting and steep dips may result mostly from doming with concurrent westward detachment of these volcanics as described for adjacent Quartz Mountain block. Tmr typically dips 20-30° NE, and Tma 10-20° NE within this block (Wahl et al., 1997; Hausback and Frizzell, unpublished geologic map of Tolicha Peak 7.5' quadrangle), suggesting that most or all doming predated Tm, with NE dips probably the result of later, superimposed Basin-Range faulting.	516.7	4126.3	
Lower Tolicha Wash	LTLW	Structurally high extracaldera block. Pre-Tm units are probably detached. Units exposed in this block and their structural attitudes (Wahl et al., 1997; Hausback and Frizzell, unpublished geologic map of Tolicha Peak SW 7.5' quadrangle) are very similar to those of the Quartz Mtn Dome block, and the Isostatic gravity signature (Figure 1) is similar, suggesting shallow depths to the pre-Tertiary surface. Dips on Tqt are more gentle westward (10-15°), and dips on Tmr more gentle eastward (15°) compared to those in the adjacent Tolicha Peak block.	502.7	4128.2	Ts (EW) 1720, Tt (EW) 1585, Tm (EW) 1570, Tbg (EW) 1430, Tq (EW) 1370

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Quartz Mountain	QZMT	Structurally high, highly faulted block with units progressively markedly older towards the southeast. TP/AFB1, near center of block, penetrated intervening gravel between Tma, Tmr, as well as bounding these units, and indicates that Tq is structurally intermediate (structural data in this table from Noto et al., 1999, slightly modified with more recent unpublished work by R. G. Warren). Extracaldera Tq, probably near Tolicha Peak caldera, dominates exposed units in southern part of block, and typically dips 30-50° away from Quartz Mountain (Wahl et al., 1997; Hausback and Frizzell, unpublished geologic map of Tolicha Peak 7.5' quadrangle; Noble and Christiansen, 1968). The extreme faulting and steep dips may result mostly from doming with concurrent westward detachment of these volcanics from structurally very high pre-Tertiary in northeastern corner of block, where a tiny outcrop of paleozoic carbonate is exposed (Wahl et al., 1997; Noble and Christiansen, 1968). This pre-Tertiary is the structurally highest northwest of Timber Mtn and is associated with the highest Bouger gravity (which trends westward across Tolicha Peak) within an extensive region (Healey et al., 1978); these data are consistent with a breakaway zone for detachment faulting. Such a breakaway zone would occur where tilts change from SE on the hanging wall to NW on the footwall. Although Carr (1990) does not address this region of the SWNVF, extrapolation northward of the boundary in his Figure 5 coincides precisely with location of a breakaway zone in this block. Tmr typically dips 20-30° NE, and Tma 10-20° NE within this block (Wahl et al., 1997; Hausback and Frizzell, unpublished geologic map of Tolicha Peak 7.5' quadrangle), suggesting that most or all doming predated Tm, with NE dips probably the result of later, superimposed Basin-Range faulting.	519.4	4128.9	QTa 1734, Tt (EW) 1722, Tg 1709, Tfs (EN) 1699, Tg 1693, Tma (EW) 1475, Tg 1419, Tmr (EW) 1347, Tg 1228, TD 1125
South of Quartz Mountain	SQZM	Structurally high, highly faulted block with units progressively older towards the northeast, and thick Tq dominating exposed units, extracaldera near source caldera, or alternatively intracaldera within Tolicha Peak caldera (Grauch et al., 1999; Fridrich et al., 1999a). Tq typically dips 30-50° away from Quartz Mountain (Fridrich et al., 1999b; Minor et al., 1998; Wahl et al., 1997; Hausback and Frizzell, unpublished geologic map of Tolicha Peak 7.5' quadrangle; Noble and Christiansen, 1968; Orkild, unpublished geologic map of Springdale NE 7.5' quadrangle). The extreme faulting and steep dips may result mostly from doming with concurrent westward detachment of these volcanics as described for adjacent Quartz Mountain block. Tmr typically dips 20-30° NE, and Tma 10-20° NE within this block (Wahl et al., 1997; Hausback and Frizzell, unpublished geologic map of Tolicha Peak 7.5' quadrangle), suggesting that most or all doming predated Tm, with NE dips probably the result of later, superimposed Basin-Range faulting.	516.7	4126.2	Tm (EW) 2150, Tq (EW) 2040
Upper Tolicha Wash	UTLW	This block forms a N-trending graben that deepens northward, together with the Tolicha Basin block. These blocks are bounded by the Upper Tolicha Wash and Tolicha Peak blocks.	512.5	4123	
Tolicha Basin	TOLB	This block forms a N-trending graben that deepens southward, together with the Tolicha Basin block. These blocks are bounded by the Upper Tolicha Wash and Tolicha Peak blocks.	515.9	4117.8	

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Sleeping Butte	SLBU	Upper Tq is structurally very high, but no pre-Tq is exposed within block, and units young to north. Tq is probably domed, detached, and near caldera, or within Tolicha Peak and/or Sleeping Butte calderas.	523.2	4112.1	Tqs (IW) 1725
Southern Thirsty Canyon	STCA	Structurally intermediate to low Tm best characterized in ER/EC8 (IT Corporation, 2000c, with stratigraphic assignments modified from more recent unpublished work by R. G. Warren). The isostatic gravity (Figure 1) is similar to that of Northern Thirsty Canyon block, although Tt generally dips W. Like the Eastern Oasis Valley block, this block lies outboard of the Transvaal Hills block from the Ammonia Tanks caldera and so must lie outside that caldera. Even so, Tm is structurally intermediate to low and only the tops of caldera-filling Tf are exposed, as in the adjacent Northwestern Timber Mtn Moat and Eastern Oasis Valley blocks. Considering the similarity of structural data between ER/EC8 and ER/EC4 within the Northern Thirsty Canyon block, this block too lies outside the Rainier Mesa caldera.	533	4106	Tt (EN) 1294, Tfm (TC) 1252, Tf (EN) 873, Tma (EW) 845, TD 684
Eastern Oasis Valley	EOVA	Structurally intermediate to low Tm. Similar to Northern Thirsty Canyon block. Tt generally dips W. This block is characterized by a single drill hole, MYJOC1, which penetrated thick Tf and bottomed in hydrothermally altered Tma (Warren et al., 2000). The block lies outboard of the Transvaal Hills block and so is clearly outside the Ammonia Tanks caldera. Considering its similarity to the Northern Thirsty Canyon block, this block lies outside the Rainier Mesa caldera. Tilts in Transvaal Hills block adjacent to east, and for Tf in eastern part of Eastern Oasis Valley block are westward (Lipman et al., 1966).	531.5	4097.5	QTa 1306, Tt? (EN) 1065, Tf (TC) 1049, Tma (EW) 451, TD 124
Transvaal Hills	TRAH	Structurally high, W-dipping Tm. Thin extracaldera Tma overlies Tmr. Byers et al. (1976a), Noble et al. (1991), and Sawyer et al. (1994) all consider westward-tilted Tmr (Lipman et al., 1966) to be intracaldera. The thickness of Tmr is conjectural, but probably 500-1000 m.	537.4	4095.8	Tma (EW) 1470, Tmr (IW) 1400
Southwestern Timber Mtn Moat	SWTM	Structurally intermediate to low Tm. Structural data from ER/EC5 (IT Corporation, 2000d, with stratigraphic assignments modified from more recent unpublished work by R. G. Warren) is consistent with a location within Ammonia Tanks and Rainier Mesa calderas.	538.8	4104.1	Tt (EW) 1548, Tma (IW) 1477, TD 786
Timber Mtn Dome	TMDO	Structurally very high, thick Tma within resurgent Ammonia Tanks caldera.	547.9	4104.5	Tma (IW) 2260
Southeastern Timber Mtn Moat	SETM	Structurally intermediate to low Tm, probably within Ammonia Tanks and Rainier Mesa calderas. Isostatic gravity signature is similar to that of Southwestern Timber Mtn Moat block, and a gravity ridge coincides with the boundary between these blocks.	551.9	4091.3	Tt (EW) 1630, Tf (TC) 1625
Claim Canyon	CLCA	Structurally very high, resurgent intracaldera Tpc of Claim Canyon caldera.	545.8	4088.2	Tp (IW) 2040
Fortymile Canyon	FOCA	Structurally high, extracaldera, SE-dipping Tp and younger. Thick Th suggests possible outer collapse zone for calderas of pre-Tp unit(s).	553.1	4085.3	Tp (TC) 1650, Th (TC) 1510
Shoshone Mtn	SHOM	Structurally very high, extracaldera, NW-dipping Tp and younger. Thick Th suggests possible outer collapse zone for calderas of pre-Tp unit(s).	560.1	4087.3	Tm (EW) 2020, Tp (EW) 1850, Th (TC) 1610

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Wahmonie-Mid Valley	WMVA	Extracaldera basin, structurally intermediate in south to low in north within UE14B (Warren et al.,2000).	575.4	4087.3	QTa 1325, Tt (EN) 959, Tm (EW) 913, Tp (EW) 624, TD 203
CP Basin	CPBA	Extracaldera basin, structurally intermediate in southwest to low in northeast within WW4A (Thompson, 1990).	586.6	4084.4	QTa 1099, Tm (EW) 870, Tp (EW) 695, Th/Tc (EN) 657, TD 637
CP Hogback	CPHO	Structurally intermediate pre-Tertiary within a south-tilted horst as represented by WWC (Drellack and Thompson, 1990).	588.2	4086.1	QTa 1195, Tp (EW) 1130, Th/Tc (EN) 1040, Tn (EN) 994, To (EN) 826, pre-T 782
Frenchman Flat	FRFL	Deep extracaldera basin with structurally low pre-Tertiary, as represented by recent unpublished work by R. G. Warren for ER5/3/2.	594.7	4081.1	QTa 1022, Tyb (LF) 747, Tg 738, Tma (EW) 400, Tmr (EW) 319, Tm (EN) 169, Tpt (EW) 147, Th (EN) 95, Tw (EN) 86, Toy (EN) -158, pre-T -404
Rock Valley	ROVA	Block has structurally intermediate pre-Tertiary, as represented by TWF (Poole et al., 1965). Outcropping units young northwestward.	578.9	4068.3	Tw (LF) 1260, Tc (EW) 811, To (EN) 742, pre-T 307
Skull Mtn	SKUM	Structurally high block. Tm through Tw generally SE-tilted.	573.4	4070.7	Tm (EW) 1860, Tw (TC) 1680
Little Skull Mtn	LSKM	Extracaldera basin, structurally intermediate at Little Skull Mtn in south to low within J11 (McKay and Williams, 1964) at Jackass Flats in north.	563.8	4071.1	QTa 1050, Tf (LF) 738, Tp (EW) 700, TD 405
Yucca Mtn	YUCM	Structurally intermediate block, as represented by UE25P1 (Warren et al., 2000). Extracaldera Tm through Tc dips SE, but pre-Tertiary surface dips NE.	551.5	4075.7	QTa 1114, Tm (EW) 1075, Tp (EW) 1062, Th (EN) 733, Tc (EW) 678, Tr (EN) 241, Tq (EN) -24, Tu (EN) -58, To (EN) -80, pre-T -130

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Crater Flat	CRFL	Deep extracaldera basin as represented by USWVH2 (Carr, 1982), possibly intracaldera for Tc and older units.	537.7	4073.2	QTa 974, Tf (LF) 615, Tm (EW) 585, Tp (EW) 379, Tc (EW) -164, TD -245
Prospectors Pass	PRPA	Structurally high, S-dipping block. Possibly intracaldera for Tct and older units.	536.2	4091.5	Tp (EW) 1650, Th (EN) 1460, Tc (E?W) 1440
Lower Beatty Wash	LBWA	Isostatic gravity (Figure 1) indicates that this block is structurally intermediate. This block exposes only thin, extracaldera Tmr and underlying Tmrf. Tilts on Tmr are more gentle in this block than in the Bare Mtn block adjacent to the south, where the volcanic section is detached (Carr and Monsen, 1988), but both Tmr and Tmrf are only slightly structurally lower in the Lower Beatty Wash block. Due to the structural similarity of the two blocks, it is very likely that the volcanic section is also detached in the Lower Beatty Wash block, as shown in cross section B of Fridrich et al. (1999b).	528.7	4089.9	Tmrf (TC) 1260
Bare Mtn	BARM	This block exposes structurally very high pre-Tertiary (Wahl et al., 1997; Streitz and Stinson, 1977), and detached volcanics on the northeast end (Monsen et al., 1992; Maldonado, 1990; Maldonado and Hausback, 1990; Carr and Monsen, 1988). Line A-A' of Healey and Miller (1965), parallel to and about 3.5 km SE from the cross sectional line of this document, estimates a maximum alluvium thickness between 670 and 1100 m for the unnamed basin west of the Bare Mtn block.	530.1	4081.7	Pre-T 2100
Bullfrog Hills	BULH	This block is structurally high. Tf through To is detached from pre-Tertiary in thin, generally steeply E-dipping fault blocks (Maldonado, 1990; Maldonado and Hausback, 1990).	515.6	4086.7	
Oasis Mtn	OASM	This block is structurally high to intermediate, probably detached, but with Tma and Tf successively less rotated eastward by detachment.	522	4098.8	Tma (EW) 1460
Tracking Station	TRAS	This block is structurally intermediate. It is unknown if pre-Tertiary detached from Tm and older volcanics.	516.2	4103.8	Tfn (LF) 1510
Sarcobatus Flat	SAFL	Isostatic gravity (Figure 1) indicates that this block represents an extracaldera basin with pre-Tertiary at intermediate structural levels. A sharp decrease in Bouger gravity (Healey et al., 1978) indicates that the pre-Tertiary in this block has been downfaulted to substantially lower elevations than in the Lower Tolicha Wash block adjacent to the east.	500.8	4096.5	QTa 1250

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Central Area 19	CA19	Thick Tcbl fills the inner collapse zone of Area 20 caldera, and moderately thin Tbg fills the western end of the Grouse Canyon trap-door caldera in PM1, as supported by data in this table (Warren et al., 2000). This block is structurally still higher than the Eastern Area 20 block adjacent to the west within Th, owing to pre-Th episodic displacement along the West Greeley fault (Warren et al., 1985), but otherwise structurally similar. Data are best represented by U20AP west of the East Greeley fault and by U19AU east of this fault to the top of Th (Warren et al., 2000) Elevations for older units and for the pre-Tertiary surface are estimated from Figure 10 in Ferguson et al. (1994) and Healey et al. (1978).	552.7	4125.9	Tm (EW) 1999, Tp (TC) 1819, Th/Tc (TC) 1646, Tcbl (IN) 1042, Tbd (LF) 396, Tbg (LF) -116, Tbq (LF) -323, TD -393
Eastern Pahute Mesa	EPME	Thick Tcbl fills the inner collapse zone of Area 20 caldera, and thick Tbd and thin Tbg fill the outer collapse zone of Grouse Canyon caldera. This block is structurally still higher than the Central Area 19 block adjacent to the west, but otherwise structurally similar down through Tc. It differs from Central Area 19 block in being within outer collapse zone of Grouse Canyon caldera rather than inner collapse zone (Ferguson et al., 1994). Data are best represented in this table by UE19I west of the Scrugham Peak fault, and by UE19P1 east of this fault (Warren et al., 2000). Elevations for the pre-Tertiary surface (>1 km below sea level) are found in Figure 10 in Ferguson et al. (1994).	557.9	4122.6	Tm (EW) 2085, Tp (TC) 1824, Th/Tc (TC) 1427, Tcb (IN) 1201, Tbd (LF) 600, Tbg (EW) 125, TD -354
Southern Area 19	SA19	Thick Tci and thin Tcbl occur within outer collapse zone of Area 20 caldera in UE19F\S (Warren et al., 2000), where thick Tbgs, precursor lava for Grouse Canyon caldera, indicates a position immediately south of that caldera.	556.1	4119.8	Tm (EW) 2053, Tp (TC) 1751, Th/Tc (TC) 1318, Tcb (EN) 593, Tbg (LF) 500, Tbq (LF) 117, TD -67
South Face of Pahute Mesa	SFPM	ER20/2/1 penetrates thin Tm and thick Tp (Warren et al., 2000) in a structurally high block, probably eroded rim of Tp caldera. Northern Timber Mtn Bench block, immediately adjacent to south, lies within Ammonia Tanks caldera, probably within Rainier Mesa caldera, and possibly within Tiva Canyon and/or Topopah Spring calderas.	553.2	4118.5	Tm (EW) 2042, Tp (TC) 1893, Th (TC) 1396, TD 1356
Northern Split Ridge	NSPR	Structurally very high to high Tm through Tot were penetrated in UE19W1 (Warren et al., 2000). The similarity of To in UE19W1 and TW8 in adjacent Southern Split Ridge block indicates that pre-Tertiary lies perhaps a few hundred meters below TD in UE19W1. The elevation for the pre-Tertiary surface, 0.8 km elevation from Figure 10 in Ferguson et al. (1994), is consistent with these observations.	560.5	4120.3	Tm (EW) 2164, Tp (TC) 1815, Th/Tc (TC) 1731, Tcb (EN) 1658, Tbd (LF) 1612, Tbg (EN) 1418, Tbq (LF) 1313, To (EN) 1245, TD 1130
Southern Split Ridge	SSPR	Structurally very high Tm through Tn occurs in TW8 (Warren et al., 2000), but thick Tor and Tot are possibly intracaldera. Prevalent clasts of granite in Tlt near TD indicate pre-Tertiary surface just below, near sea level.	563.1	4113.3	Tm (EW) 1736, Tr (EN) 1690, Tbq (LF) 1494, To (IW) 1123, Tlt 127, TD 62

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM) E	Location (km UTM) N	Strat, hydrogeol, top elev (m) at location
Big Burn Valley	BBVA	Structurally very high Tm through Tn is similar to that of adjacent Southern Split Ridge block. Pre-Tertiary is structurally high to intermediate, even though thick, possibly intracaldera Tor occurs in ER19/1 (Warren et al., 2000), just east of structural block.	567.5	4114.7	Tbg (EW) 1871, Tn (EN) 1761, To (IW) 1545, Tlt 1003, pre-T 987
Rainier Mesa	RAIN	Very high structural levels are documented in UE12E3 (Warren et al., 2000). Westward dipping pre-Tertiary outcrops in eastern part of block.	569.5	4115.3	Tm (EW) 2275, Tp (EN) 2129, Th/Tc (EN) 2086, Tbg (EW) 1052, Tn (EN) 1900, Tub (EN) 1732, To (EN) 1726, TD 1605
Eleana Range/Calico Hills	ERCH	This block is structurally very high. Pre-Tertiary widely crops out, draped with volcanics that thicken westward and over eroded southern end of block.	569.2	4100.1	Tp (EW) 2040, Th/Tc (EN) 1950, Tr (EN) 1800, Tn (EN) 1700, To (EN) 1660, pre-T 1550
Western Yucca Flat	WYFL	Similar to Central Yucca Flat block, with structurally intermediate pre-Tertiary, but with an intermediate thickness of alluvium, and volcanics as represented by TWD (Dixon et al., 1973).	582.2	4103.3	QTa 1266, Tn?? (EN) 804, pre-T 738
Central Yucca Flat	CYFL	Similar to Western Yucca Flat block, with structurally intermediate pre-Tertiary, but with thick alluvium, and an intermediate thickness of volcanics in UE7BA (Warren et al., 2000).	584.9	4104.8	QTa 1259, Tm (EW) 1163, Tp (EN) 946, Th/Tc (EN) 914, Tn (EN) 794, To (EN) 657, pre-T 529
Southern Halfpint Range	SHAR	Pre-Tertiary is structurally high, cropping out in eastern part of block, to low in western part within UE6E (Drellack and Thompson, 1990), dipping southwestward. Alluvium and volcanics thicken strongly southwestward.	587	4093.4	QTa 1200, Tm (EW) 783, Tp (EW) 668, Th/Tc (EN) 526, Tn (EN) 380, To (EN) 310, pre-T -15
			596.3	4087.4	Tm (EW) 1440, Tp (EW) 1370, Th/Tc (EN) 1350, pre-T 1130
CP Hills	CPHI	Pre-Tertiary is structurally very high in eastern part of block, dipping southwestward. Volcanics thicken strongly southwestward.	579.6	4089	Tp (EW) 1620, Th/Tc (EN) 1510, pre-T 1460

Table 1 (continued). Descriptions for structural blocks of the SWNVF

Block	Code	Description	Location (km UTM)		Strat, hydrogeol, top elev (m) at location
			E	N	
Eastern Timber Mtn Bench	ETMB	Structurally intermediate Tm occurs within ER30/1 (Warren et al., 2000), possibly within Rainier Mesa caldera.	560.8	4100.5	QTa (EW) 1416, Tfb 1300 (IN), Tf (LF) 1127, Tma (IW) 1052, TD 1020
Northeastern Timber Mtn Bench	NETB	Structurally intermediate Tm in UE18T (Warren et al., 2000) includes extracaldera Tma, probably deposited within Rainier Mesa caldera. Probably east-dipping block structurally similar to or continuous with Northern Timber Mtn Bench.	559.6	4109.1	QTa 1585, Tt (EW) 1494, Tf (TC) 1454, Tma (EW) 1299, Tmr (I?W) 1145, TD 793
Northern Timber Mtn Bench	NTMB	Structurally high extracaldera Tma, probably within Rainier Mesa caldera. Probably east-dipping block structurally similar to or continuous with Northeastern Timber Mtn Bench block. Mankinen et al. (1999) model relatively high isostatic gravity values to calculate a relatively thin section of volcanic rocks above a "basement ridge" within the western part of this block. This feature is contiguous into the adjacent Northwestern Timber Mtn Bench. Elevation layers for the 3-D geologic model of this report show that these two blocks have highly different structural character, so that similar thicknesses of volcanic rock are unlikely. Extreme alteration within ER/EC6, within the Northeastern Timber Mtn Bench block, suggests that the gravity feature instead reflects relatively high densities localized by hydrothermal alteration along the Boxcar fault, which bounds the block on the west and bisects the gravity feature.	548.8	4115.2	Tmat (TC) 1810
Northeastern Timber Mtn Moat	NETM	Structurally intermediate Tm in ER18/2 (IT Corporation, 2000a) includes intracaldera Tma, probably also within Rainier Mesa caldera.	555.6	4106.4	Typ (LF) 1657, Tt (EW) 1575, Tf (TC) 1550, Tma (IW) 1428, TD 895
Northern Timber Mtn Moat	NTMM	Structurally intermediate to low Tm occurs in UE18R (Warren et al., 2000), within the Ammonia Tanks and Rainier Mesa calderas.	549.3	4109.8	Tt (EW) 1688, Tf (TC) 1585, Tma (IW) 1363, Tmr (IW) 504, TD 163
Northwestern Timber Mtn Moat	NWTM	Structurally intermediate to extremely low Tm occurs in ER/EC2A, within the Ammonia Tanks caldera, and probably within the Rainier Mesa caldera. Extremely thick Tfb fills the Ammonia Tanks caldera. The block is surrounded by blocks that are structurally higher, especially the Northwestern Timber Mtn Bench block, which exposes Ammonia Tanks Tuff 1.2 km above its level in ER/EC2A, as seen in the elevation layer for this report. Mankinen et al. (1999) model relatively low isostatic gravity values to calculate an extremely thick section of volcanic rocks, consistent with the structural data from ER/EC2A.	538.4	4111.1	Tfb (TC) 1481, Tf (IN) 539, Tma (IN) 518, TD -35

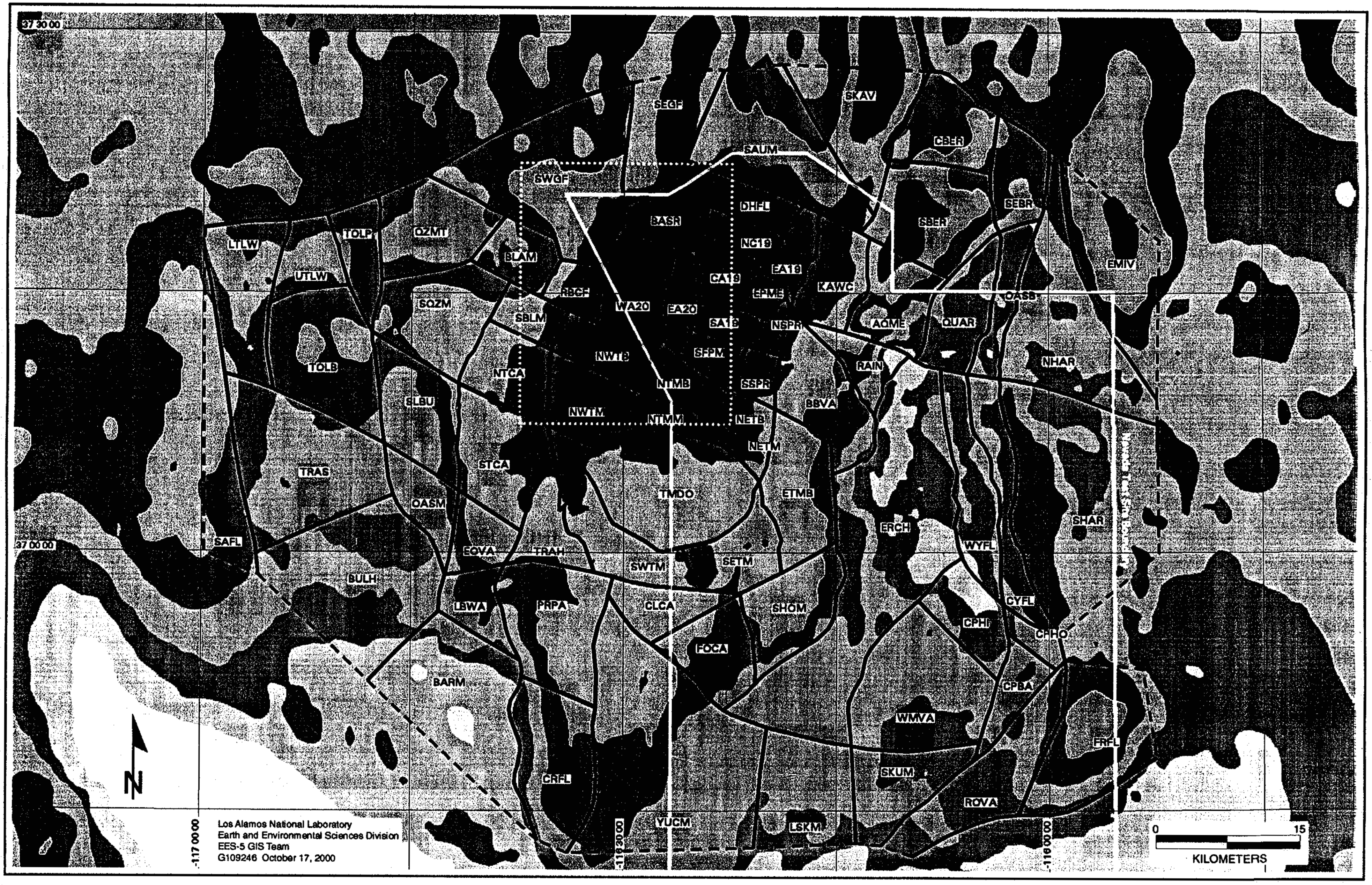

Figure 1. Structural blocks of the southwestern Nevada volcanic field, compared to the isostatic residual gravity field of the region (Hildenbrand et al., 1999). Darkest red shading represents gravity minima (<-60 mgal), and lightest blue shading represents gravity maxima (>10 mgal). Symbols for structural blocks are defined in Table 1. The three dimensional model of this report represents the outlined area north of the Timber Mountain Dome (TMDO) structural block. Dashed line denotes limit of model rather than block boundary.

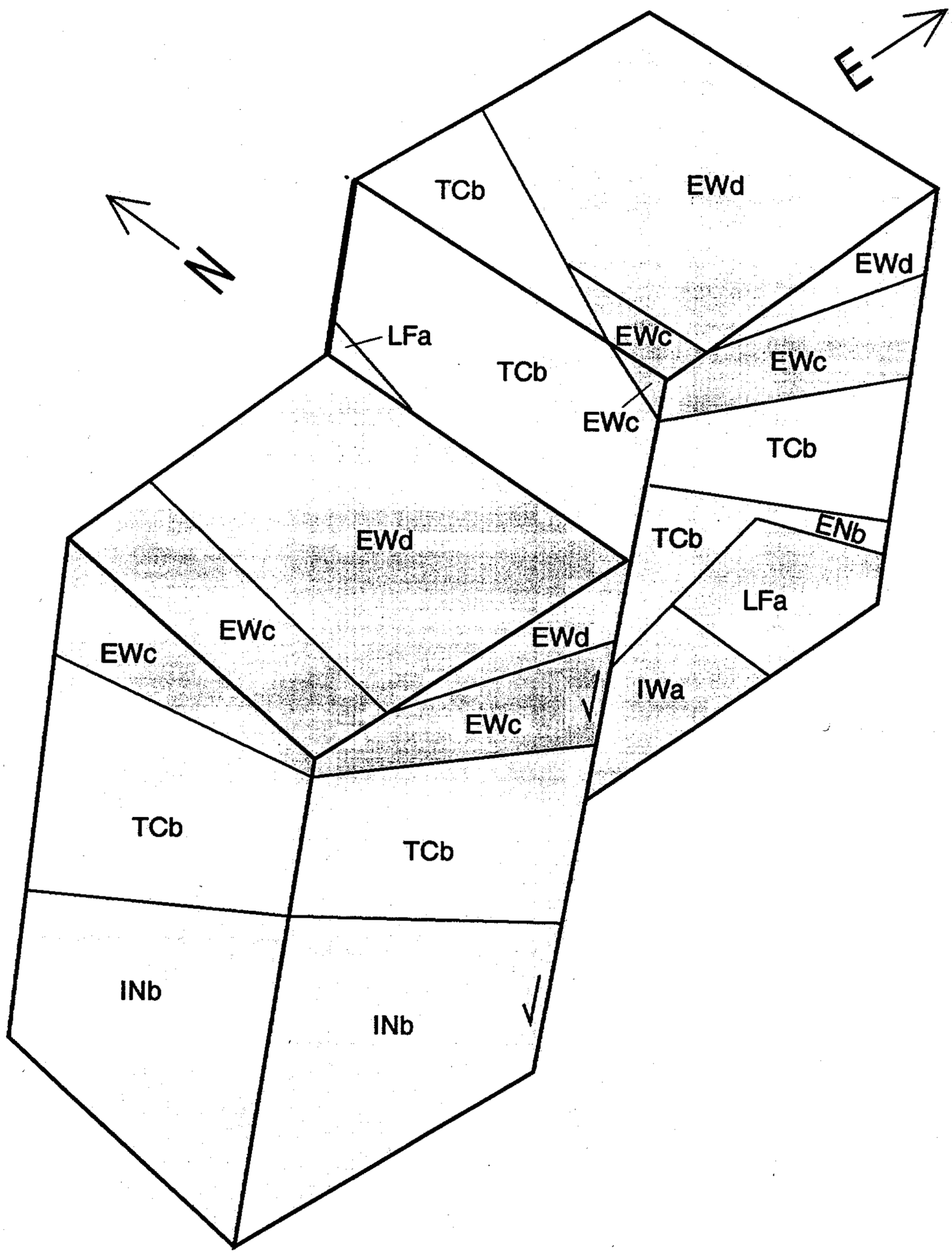

Figure 2. Block diagram that illustrates assignment of hydrogeologic units. First two letters of symbols indicate hydrogeologic unit as shown in Table 6; third letter designates stratigraphic group (e.g., Paintbrush Group). Several structural complexities, all of which occur within the Silent Canyon caldera of Pahute Mesa subsurface, are represented here. Group "d" is an extracaldera welded tuff (e.g., Ammonia Tanks Tuff). It has been rotated eastward in both blocks and downdropped in the western block. The top of this hydrogeologic unit, stripped off in this view, is an east-dipping plane. Group "c" is an older extracaldera welded tuff (e.g., Rainier Mesa Tuff). It has been rotated eastward in both blocks and downdropped in the western block. The top of this hydrogeologic unit is also an east-dipping plane. Below these units is a much thicker sequence of near-caldera and intracaldera units of group "b" (e.g., Calico Hills Formation and lithic-rich Bullfrog Tuff). The units of group "b" have rotated eastward during several episodes, and also the eastern block has rotated southward while the western block rotated northward, resulting in a thickening of these and overlying units in the direction of rotation (NE in the western block, SE in the eastern block). Below group "b" lies still another near-caldera and intracaldera "a" group (e.g., Belted Range Group). Although genetically complex, the layers can be well approximated by one or more planes that define the top of each layer. Hydrogeologic unit TCb was deposited within an eroded caldera wall in the eastern block; here, two planes are needed to define the extent of this unit. **Note that minor structures, most generally faults with displacements <100 m, are ignored within each structural block. Note also that both blocks might be buried by an even younger unit "e", and structurally indistinguishable at young stratigraphic levels.**

on the accompanying map, as illustrated in Figure 2 and in Figures 22 and 27 of Warren et al. (1985). Hudson et al. (1994) have demonstrated that vertical axis rotation is not important for blocks within the central part of the SWNVF. The units, their thicknesses, and attitudes define a unique structural history for each structural block, which can be related to episodic reactivation of faults that bound the block (Figure 25 in Warren et al., 1985). When faults that bound two or more structural blocks are inactive during a certain episode, then these blocks have a similar structural history at that time and they are indistinguishable at the top of that particular stratigraphic level.

Table 2. Key to symbols used for stratigraphic units in Table 1

Stratigraphic unit symbols and definitions follow Warren et al. (2000); ages are from Sawyer et al. (1994) and Warren et al. (2000). Stratigraphic assemblages are in bold, units within three dimensional model are in italics. Hydrogeologic types are: *Weld*, generally welded ash-flow tuff; *Nonw*, intracaldera nonwelded tuff; *LF*, generally lava flows with little associated tuff; *TC*, generally lava flows are associated with tuff-cone precursors. A *p* added to *LF* or *TC* indicates caldera precursor; all others *fill* calderas.

Symbol	Unit	Hydr type	caldera	age (Ma)
QTa	alluvium			
Typ	Pliocene basalts	LF		
Tg	Pliocene through Oligocene alluvium			
Tyb	Post-Thirsty Canyon basalts	LF		
Ts	**Volcanics of Stonewall Mountain**		Stonewall Mtn	7.6
Tyb	Post-Thirsty Canyon basalts	LF		
Tt	**Thirsty Canyon Group**		Black Mtn	9.4
Tth	trachyte of Hidden Cliff	LF	Black Mtn	
Ttt	Trail Ridge Tuff	Weld	Black Mtn	
Ttp	*Pahute Mesa Tuff*	Weld	Black Mtn	
Ttc	*comendite of Ribbon Cliff*	LFp		
Tf	**Volcanics of Fortymile Canyon**			
Tfs	rhyolite of Shoshone Mountain	LF		
Tfn	latite of Donovan Mountain	LF		
Tfm	rhyolite of Max Mountain	TC		
Tfb	*Beatty Wash Formation*	TC		
Tm	**Timber Mountain Group**			
Tma	*Ammonia Tanks Tuff*	Weld	Ammonia Tanks	11.45
Tmat	*rhyolite of Tannenbaum Hill*	TCp	Ammonia Tanks	
Tmr	*Rainier Mesa Tuff*	Weld	Rainier Mesa	11.6
Tmrf	*rhyolite of Fluorspar Canyon*	TCp	Rainier Mesa	
Tmrh	*tuff of Holmes Road*	Nonw		
Tmt	*basalt of Tierra (included with Tmrh)*	LF		
Tmw	*rhyolite of Windy Wash*	LF		
Tp	**Paintbrush Group**			
Tpb	*rhyolite of Benham*	TC		
Tps	*rhyolite of Scrugham Peak*	LF		
Tpc	*Tiva Canyon Tuff*	Weld	Claim Canyon	12.65
Tpd	*rhyolite of Delirium Canyon*	TC		
Tpe	*rhyolite of Echo Peak*	TC		
Tpr	*rhyolite of Silent Canyon*	LF		
Tptx	*Breccia of Topopah Spring Tuff (included with Tpr)*	Nonw		
Tpt	*Topopah Spring Tuff*	Weld		12.7

Table 2. Key to symbols used for stratigraphic units in Table 1 (continued)

Symbol	Unit	Struct type	caldera	age (Ma)
Th	**Calico Hills Formation**			
Thp	*Mafic-poor Calico Hills Formation*	TC		
Thr	*Mafic-rich Calico Hills Formation*	TC		
Tw	**Wahmonie Formation**			
Tc	**Crater Flat Group**			
Tcu	*tuff of Pool (included with Tci)*	Nonw		
Tci	*rhyolite of Inlet*	LF		
Tcf	*basalt of Fontina (included with Tci)*	LF		
Tcj	*rhyolite of Jorum*	TC		
Tcpe	*rhyolite of ER/EC1 (included with Tcps)*	TC		
Tcps	*rhyolite of Sled*	TC		
Tcpk	*rhyolite of Kearsarge*	LF		
Tcg	*andesite of Grimy Gulch (included with Tcpk)*	LF		
Tcb	*Bullfrog Tuff*			
Tcbl	lithic-rich	Nonw	Area 20	13.1
Tcbs	Stockade Wash lobe	Nonw		13.1
Tcbp	rhyolite of Prospectors Pass	LFp		
Tct	*Tram Tuff (included with Tcb)*	Weld		
Tb	**Belted Range Group**			
Tbd	Dead Horse Flat Formation	LF		
Tbg	Grouse Canyon Tuff	Weld	Grouse Canyon	13.6
Tbgb	Bedded Grouse Canyon Tuff	Nonw		
Tbgs	comendite of Split Ridge	LFp		
Tbq	comendite of Quartet Dome	LFp		
Tr	**Tram Ridge Group**			
Tn	**Tunnel Formation**			
Tq	**Volcanics of Quartz Mountain**			
Tqs	tuff of Sleeping Butte	Weld		
Tqt	tuff of Tolicha Peak	Weld		
Tqb	Biotite-bearing rhy of Quartz Mtn	TCp		
Tqm	dacite of Mt. Helen	LFp		
Tu	**Volcanics of Big Dome**			
Tuo	rhyolite of Ochre Ridge	LF		
Tub	Tub Spring Tuff	Weld		14.9
To	**Volcanics of Oak Spring Butte**			
Tor	Redrock Valley Tuff	Weld		
Tot	tuff of Twin Peaks	Weld		15.4
Tk	**Volcanics of Kawich Valley**			
Te	**Volcanics of Central Nevada**			
Tlt	tuffaceous paleocolluvium			

Although north-south structures are often well-defined by normal faults, east-west structures are generally represented by often subtle flexures within the youngest units, which obscure both caldera-related and post-caldera structural offsets that are comparable to those of the north-south structures (Figure 22 of Warren et al., 1985). Each block is bounded by faults whose activity is primarily Miocene to Recent and thus is contemporaneous with or postdates the silicic volcanism active primarily between 16 and 7.5 Ma (Sawyer et al., 1994) . Therefore all structural blocks define important Tertiary structure developed after 16 Ma. Within structural blocks dominated by pre-Tertiary rocks, older, much more complex structures dominate (Cole and Cashman, 1999; Monsen et al., 1992; Carr and Monsen, 1988; Barnes et al., 1982). We do not address these pre-Tertiary structures.

Byers et al. (1976a) describe an arcuate "tuff dike zone" within the Timber Mountain Dome structural block, which provides direct evidence for the existence of arcuate volcano-tectonic structures within the SWNVF. From this evidence, structural boundaries of the Timber Mountain Dome have been represented as arcuate in the accompanying map. This dome is a relatively young feature in the center of the SWNVF, a volcanic field which appears to have become increasingly resistant to deformation with time (Hudson et al., 1994). The decreased decoupling with regional structure can be explained by an increase in crustal strength as a subvolcanic pluton continued to grow with continued volcanism. The Black Mountain caldera, which postdates the Timber Mountain Dome and lies near the northwestern edge of the little-extended central block of the SWNVF (Hudson et al., 1994), is considered the best example within the SWNVF of a "classic" caldera bounded by arcuate structures (Sawyer et al., 1994; Byers et al., 1976a; Orkild et al., 1969). Yet this caldera is shown on our accompanying map and in Figure 1 with linear structural boundaries as the Black Mountain structural block, because bounding structures are everywhere buried by younger deposits, so that linear and arcuate structural boundaries are equally viable alternatives. Ash flow sheets of the Thirsty Canyon Group are distributed highly asymmetrically with respect to their source, the Black Mountain caldera (Wahl et al., 1997), suggesting a trap-door structure opening along a north-trending linear feature. Valles caldera, a "classic" caldera long thought to be bounded by arcuate structures, has been found to be asymmetric, and bounded by linear fault segments of the Rio Grande Rift beneath recent lake deposits (Nielson and Hulen, 1984). Like the Black Mountain caldera, its present day round topographic expression was thought to reflect original structural boundaries of the Valles caldera, but deep drilling demonstrated the error in this simplistic view. Should arcuate structural boundaries be preferred or later demonstrated for certain calderas, only minor modifications are required to convert the existing trapezoidal structural blocks into rounded ones.

A "top down" three dimensional structural model for the SWNVF

We model the three-dimensional distribution of hydrogeologic units applying a "top down" method separately for each block. We prefer a "top down" approach because structures readily recognized within units that lie near the surface frequently reveal the location and orientation of buried major structures (Warren et al., 1985). Although the 9.4 Ma Pahute Mesa Tuff is widely exposed within the SWNVF, structural features within this unit have never been applied for quantitative structural analysis, certainly because this unit postdates most of the eruptive and structural history of the volcanic field. But structural relief across this unit exceeds 500 m between certain adjacent structural blocks. Clearly, the final phases of episodic activity are accurately defined by mapping the surface of the Pahute Mesa Tuff. Where adjacent control points from subsurface for older units suggests a significant buried structural feature, we assume that the accurately defined surface of the Pahute Mesa Tuff reveals the nature of such a feature.

Within this report, we provide a three-dimensional model centered on the Western Area 20 structural block, which was the site of the largest nuclear tests within the NTS. This block coincides with the corners of four 7.5 minute geologic quadrangle maps (Byers and Cummings, 1967; Christiansen and Noble, 1968; Ekren et al., 1966; O'Conner et al., 1966). We selected approximately 1000 labeled points within each quadrangle to represent contacts between stratigraphic units or topographically high areas within vast exposures of single units. For each point, we read map units above and below the contact and elevation, then read these data into separate files for each quadrangle and digitized horizontal coordinates for all points. We confirmed locations using overlays at the 1: 24000 map scale, and map units and elevation by comparing a second reading of each point, correcting all errors during this process. We converted map units to stratigraphic units of Warren et al. (2000), considering updated stratigraphic assignments for units from the most recent regional map (Wahl et al., 1997), and from samples within the region (Warren et al., 2000). Twenty-three units, italicized in Table 2, comprehensively represent stratigraphic units within the area of the four quadrangles. Finally, we created a file for each stratigraphic unit within the region by extracting appropriate structural data from the files for each quadrangle, and adding structural data for all drill holes within the region. We obtained data for drill holes from table *geol_int* of Warren et al. (2000), updated from recent revisions for deep drill holes by Noto et al. (1999) and Prothro and Warren (2000), and for drill holes recently completed (IT Corporation, 2000a-d; Bechtel Nevada, 2000), using additional, more recent stratigraphic assignments by R. G. Warren for drill holes recently completed. In the pocket, we provide electronic files that contain all controlling structural data with this report. In drill holes where the definition of stratigraphic units is incomplete, bounds are determined for the elevations of the upper and lower contacts, and for thicknesses, according to examples in Table 3.

Table 3. Examples of controlling structural data for three dimensional model

Examples are from electronic file that accompanies this report. Symbols for stratigraphic units are defined in Table 2. All values are in meters, from Warren et al. (2000). Upper and lower contacts are elevations from Warren et al. (2000); plot values represent true elevations where a maximum or minimum is not provided but otherwise represent a limiting value. The second through fourth variables within the source file, not shown in this table, are Easting and Northing, in UTM, NAD27, and control types. Control types are EX = exploratory hole; EM = emplacement hole; and outcrop. The symbol for the 7.5 minute quadrangle where the control point resides, defined in database table *quad_list*, defines control points from outcrop.

Hole	Strat	Upper contact			Lower contact			Thickness		
ID	unit	plot	max	min	plot	max	min	plot	max	min
U20AF	Tmrf	1483	1483		-1340		1340	-143	143	0
U20AF	Tmrh	-1483	1483		-1340		1340	-143	143	0
U20AF	Tpb	-1483	1483		-1340		1340	-143	143	0
U20BB1	Tmrf	1551			-1260	1385	1260	-291	291	166
U20BB1	Tmrh	-1385	1385		1260		1260	-125	125	0
U20BB1	Tpb	1260			-1209	1240	1209	-51	51	20

Plot values within the electronic files represent true elevations where a maximum or minimum is not provided, as shown in Table 3, but otherwise represent a limiting value. An interval between 456 and 599 m depth in U20AF without stratigraphic assignment is bounded by Tmr above and Th below, and therefore may include Tmrf, Tmrh, Tpb, and additional older units, with unit symbols and stratigraphic order defined in Table 2. Any of these units may occur within U20AF with the same possible maximum thickness, as shown in Table 3, and any may be absent. To represent data for each unit, we plotted negative values for bounding elevations except for Tmrf, because the plot elevation is correct if this unit is present. Negative thicknesses were ignored in the computation of isopachs, but all structural data were visually fit to limiting data with the same criteria as for precise structural data. For U20BB1, Tmrf occurs between 347 and 513 m depths, Tpb occurs between 638 and 658 m depths, and Tpc occurs below 689 m depth, with intervals between stratigraphically unassigned. The interval directly below Tmrf could contain additional Tmrf and/or Tmrh, and the interval below Tpb could contain additional Tpb and/or Tps, as reflected in Table 3. Assumptions in Table 4 define the list of stratigraphic units that can occur within undefined stratigraphic intervals.

Table 4. Assumptions that define the list of stratigraphic units within undefined stratigraphic intervals

Symbols for stratigraphic units are defined in Table 2. Assumptions are invalid when both stratigraphic unit and lithology are not reported, reflecting an absence of information within a drill hole.

Unit	Assumption
Tmr	Lowest depth provided accurately reflects elevation of lower contact.
Tmw	This unit is distinctive and easily recognizable, and therefore accurately represented. Therefore it is absent if an undefined stratigraphic interval includes this unit.
Tpb	Shallowest depth provided accurately reflects elevation of upper contact, but additional tuff may underlie lowest depth provided or unit may not be recognized in the lithologic form of nonwelded tuff.
Tpc	This unit is distinctive and easily recognizable, and therefore accurately represented. Therefore it is absent if an undefined stratigraphic interval includes this unit.
Tpr	This unit is generally distinctive and easily recognizable in the lithologic form of lava. Therefore the shallowest depth provided accurately reflects elevation of upper contact. Additional tuff may underlie lowest depth provided or unit may not be recognized in the lithologic form of nonwelded tuff.
Thp	This unit is generally distinctive and easily recognizable in contrast with stratigraphically overlying Tp. Therefore the shallowest depth provided accurately reflects elevation of upper contact.

From plots of all control points, we hand contoured elevations for the top of each stratigraphic unit within the four quadrangle region, down through the Rainier Mesa Tuff (Tmr), but including only Pahute Mesa Tuff and comendite of Ribbon Cliff within the Thirsty Canyon Group. Faults were treated as inflections within elevations, not as discontinuities, and as locations a unit is likely to thin to zero thickness away from its source. After using commercially available software to convert digitized contours to gridded layers, we iteratively adjusted these elevation layers until minor stratigraphic inconsistencies remained. Minor inconsistencies, generally related to steep paleotopography or to faults, were resolved by slight, systematic adjustments to each gridded layer. The elevation contours by Prothro and Warren (2000) provided layers for the tops of three units within the Western Area 20 structural block: the Pahute Mesa (Ttp), Ammonia Tanks (Tma), and Rainier Mesa (Tmr) Tuffs. For older units, down through the Crater Flat Group, which are generally too deeply buried to allow accurate recognition of elevation contours, and for the thickness of the deepest unit with such contours (Tmr), we instead produced isopachs based on available subsurface and sparce outcrop data. Appending thicknesses for successively deeper units to the base of the overlying elevation layer provides a complete set of elevations to the desired depth, approximately sea level. Elevations for each stratigraphic unit beneath Rainier Mesa Tuff must agree within a few meters with known elevations within the file, except that larger discrepancies are allowed where faults or locally steep paleotopography result in contours separated by <50 m. The set of elevations for the tops of 23 units and their thicknesses, plus elevations for the bottom of the oldest unit, shown in Appendix A, provide a three dimensional geologic representation of the Western Area 20 structural block. These elevations and thicknesses are consistent with all geologic data, within the limits described above as shown in Appendix A.

The three-dimensional model reveals numerous structural and depositional features within the region, named in Appendix Figure A1. In Appendix A, we describe features that significantly control thicknesses or elevations for each unit. These features are generally related to Basin-Range faults that were active contemporaneously with deposition of units and deep basins formed by caldera collapse. Figure 3, which shows the top surface of Rainier Mesa Tuff (Tmr) and the bottom surface of Bullfrog Tuff (Tcb), graphically illustrates the markedly greater offset of 850 m across the West Greeley fault for Tcb, compared to 225 m for Tmr. Offset across this fault, and across the West Boxcar fault systematically increases with age of stratigraphic unit, as shown in Table 5, demonstrating that these faults were continuously active during the entire period that the units of this model were erupted, between 9.6 and 13.1 Ma.

Table 5. Offsets across West Boxcar and West Greeley faults for selected units from three dimensional model

Offsets are in meters, as displayed for top of unit in Appendix A. Unit symbols are defined in Table 2; ages are from Sawyer et al. (1994). Asterisk denotes data for base of unit, reflecting pre-13.1 Ma offset.

Unit	Age (Ma)	W. Boxcar	W. Greeley
Ttp	9.6	75	150
Tma	11.4	100	200
Tmr	11.6	175	225
Tpc	12.65	350	450
Thp	12.8	750	650
Tcb	13.1	850	950
Tcb*	>13.1	1100	850

Figure 4 illustrates the deep basins formed during caldera-forming eruptions in the region. Separate, deep basins have formed within the Ammonia Tanks caldera, divided by the Boxcar fault. The much deeper, westerly basin is here named the Rocket Wash basin. The older Area 20 caldera has been greatly modified into a complex, asymmetric basin by later Basin-Range faulting. Figure 5 illustrates initial filling of the Area 20 caldera with units of the Crater Flat Group. This filling was completed with deposition of the very thick Calico Hills Formation, not shown in Figure 5. Figure 6 demonstrates the dramatic decrease in elevation for each stratigraphic unit southward from the Western Area 20 structural block into the Northwestern Timber Mountain Bench block. The striking decrease may reflect a buried, west-northwest trending fault.

The surfaces and thicknesses of the three dimensional model can readily be converted from stratigraphic layers into hydrogeologic layers that will provide an accurate three-dimensional hydrogeologic model for the Western Area 20 structural block. We describe guidelines for a simple conversion below.

Hydrogeologic units

Two important problems must be addressed to properly describe hydrogeologic controls within volcanic rocks of the SWNVF. One problem is how to best define and model poorly characterized hydrogeologic units that occur where saturated rock is uncharacterized by drilling (actually, most of the SWNVF). The second problem is how to realistically model regional hydraulic characteristics of very complex lithologies, such as those typically observed in subsurface of Pahute Mesa.

The first problem might be addressed by developing a hydrogeologic model to apply where the structural environment is known, but lithology and alteration, which control hydraulic properties, are unknown.

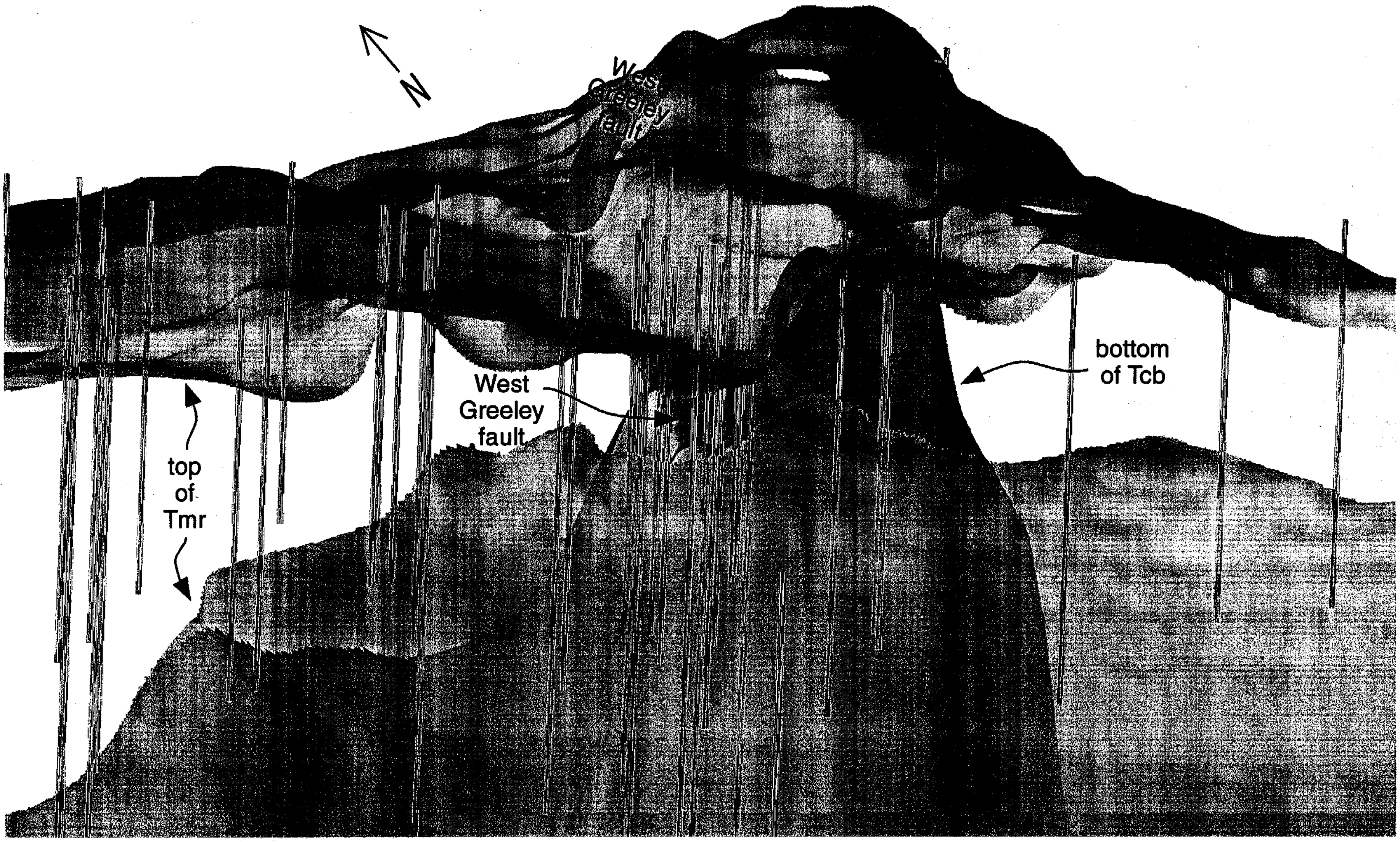

Figure 3. Three-dimensional representation in green for top surface of Rainier Mesa Tuff (Tmr), and in magenta for bottom of Bullfrog Tuff (Tcb), looking from southwest. Vertical bars show that all drill holes in this view penetrate top of Tmr, but none penetrate bottom of Tcb, defined by a "top down" model from younger units. This view graphically illustrates the markedly greater offset of 850 m across the West Greeley fault for Tcb, compared to 225 m for Tmr (Table 5).

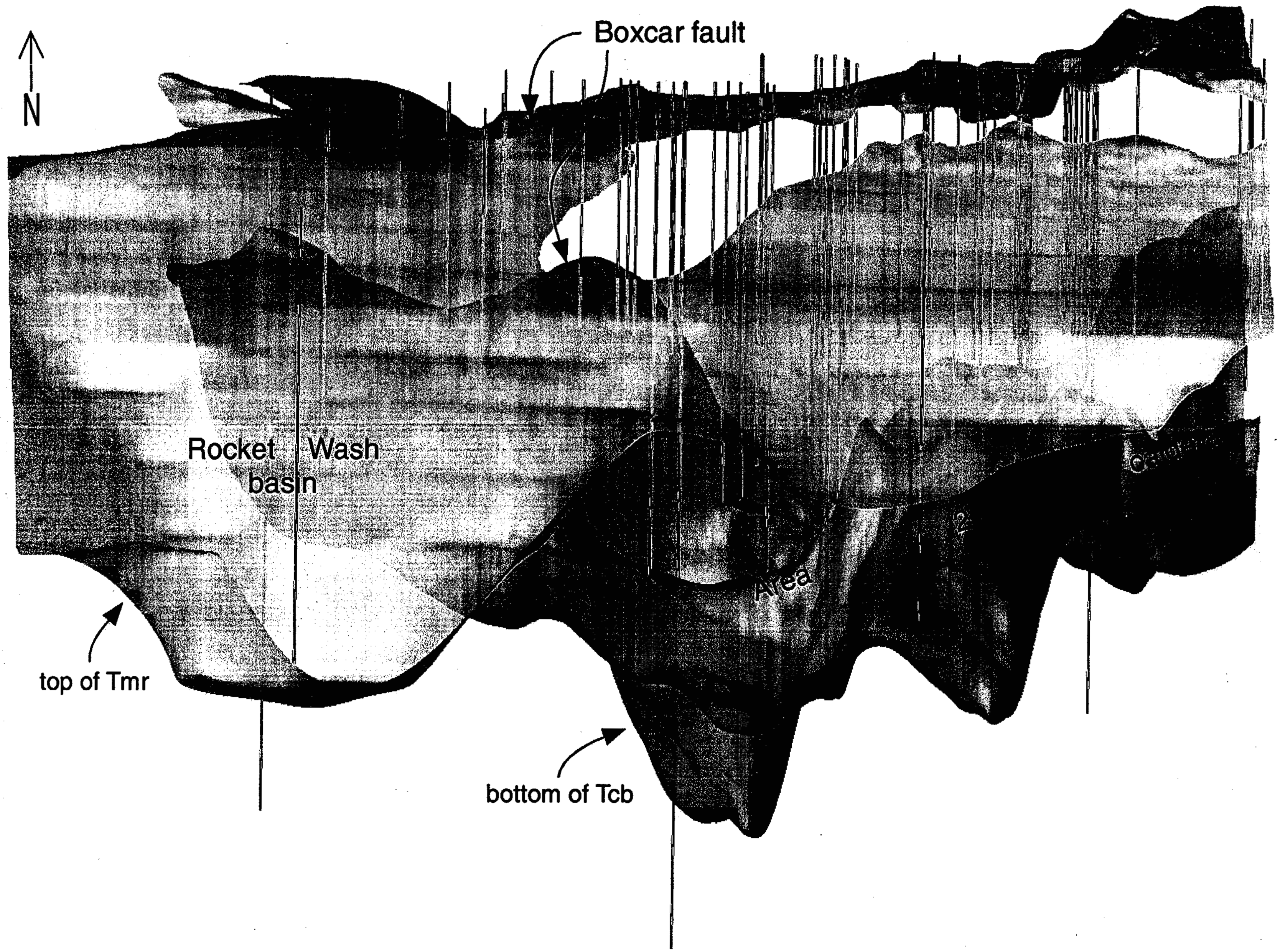

Figure 4. Three-dimensional representation in green for top surface of Rainier Mesa Tuff (Tmr), and in magenta for bottom of Bullfrog Tuff (Tcb), looking from south. Vertical bars show that all drill holes penetrate the top of Tmr, but few penetrate bottom of Tcb, defined by a "top down" model from younger units. This view graphically illustrates that separate, deep basins occur within the Ammonia Tanks caldera, divided by the Boxcar fault. The much deeper, westerly basin is here named the Rocket Wash basin. The older Area 20 caldera has been greatly modified into a complex, asymmetric basin by later Basin-Range faulting.

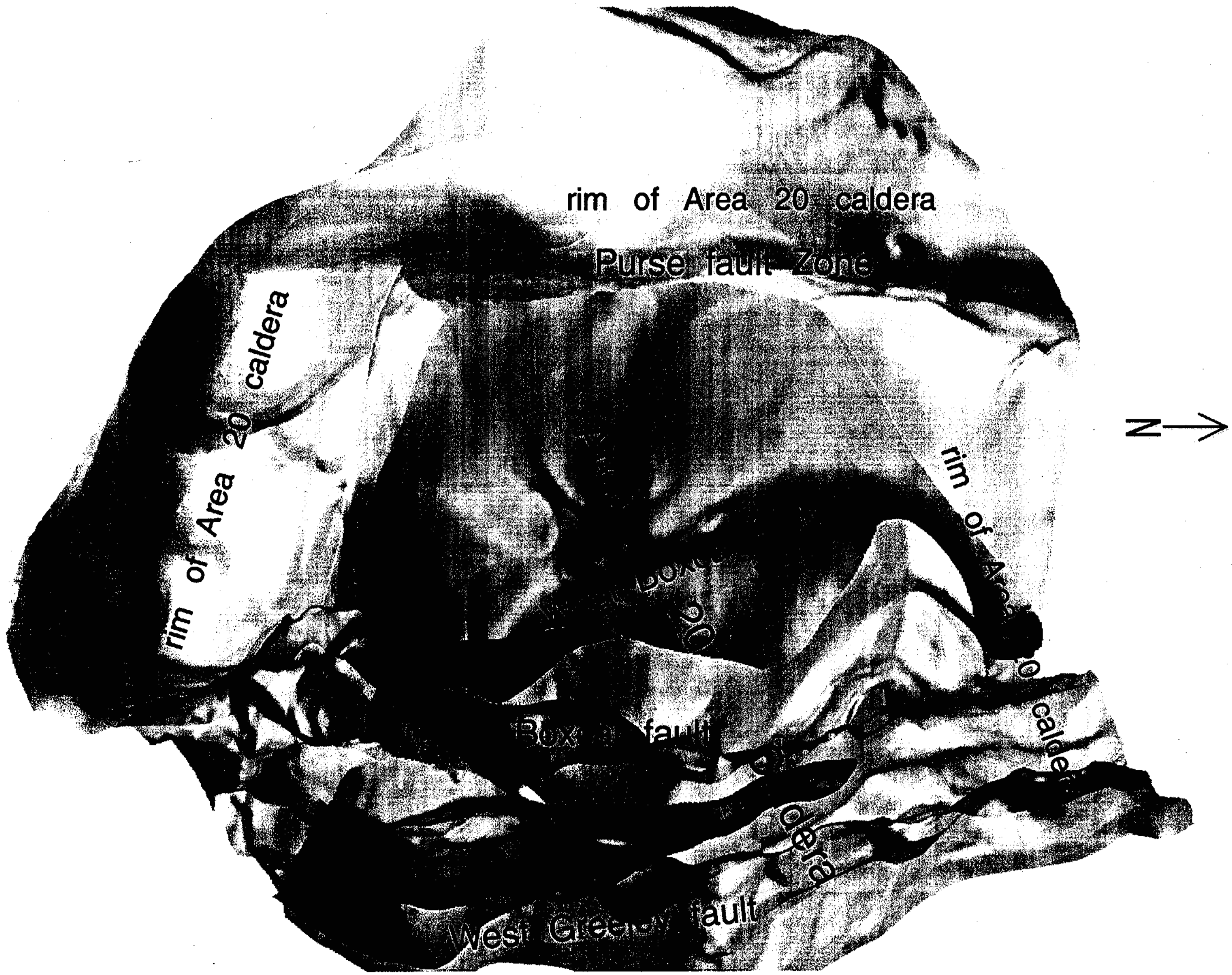

Figure 5. Three-dimensional representation in magenta for bottom of Bullfrog Tuff (Tcb), in blue for rhyolite of Kearsarge (Tcpk), and in purple for rhyolite of Inlet (Tci), looking down 45 degrees from east. This view shows that Tcpk, erupted immediately following formation of the Area 20 caldera, did not fill the caldera. Rhyolites of Sled and ER/EC1, which immediately succeeded Tcpk, also did not fill the Area 20 caldera; the distribution of these three units might therefore be attributed to resurgence. But all later units associated with the Area 20 caldera, such as Tci and Calico Hills Formation, show maximum thicknesses that coincide with the caldera; such thicknesses are inconsistent with resurgence.

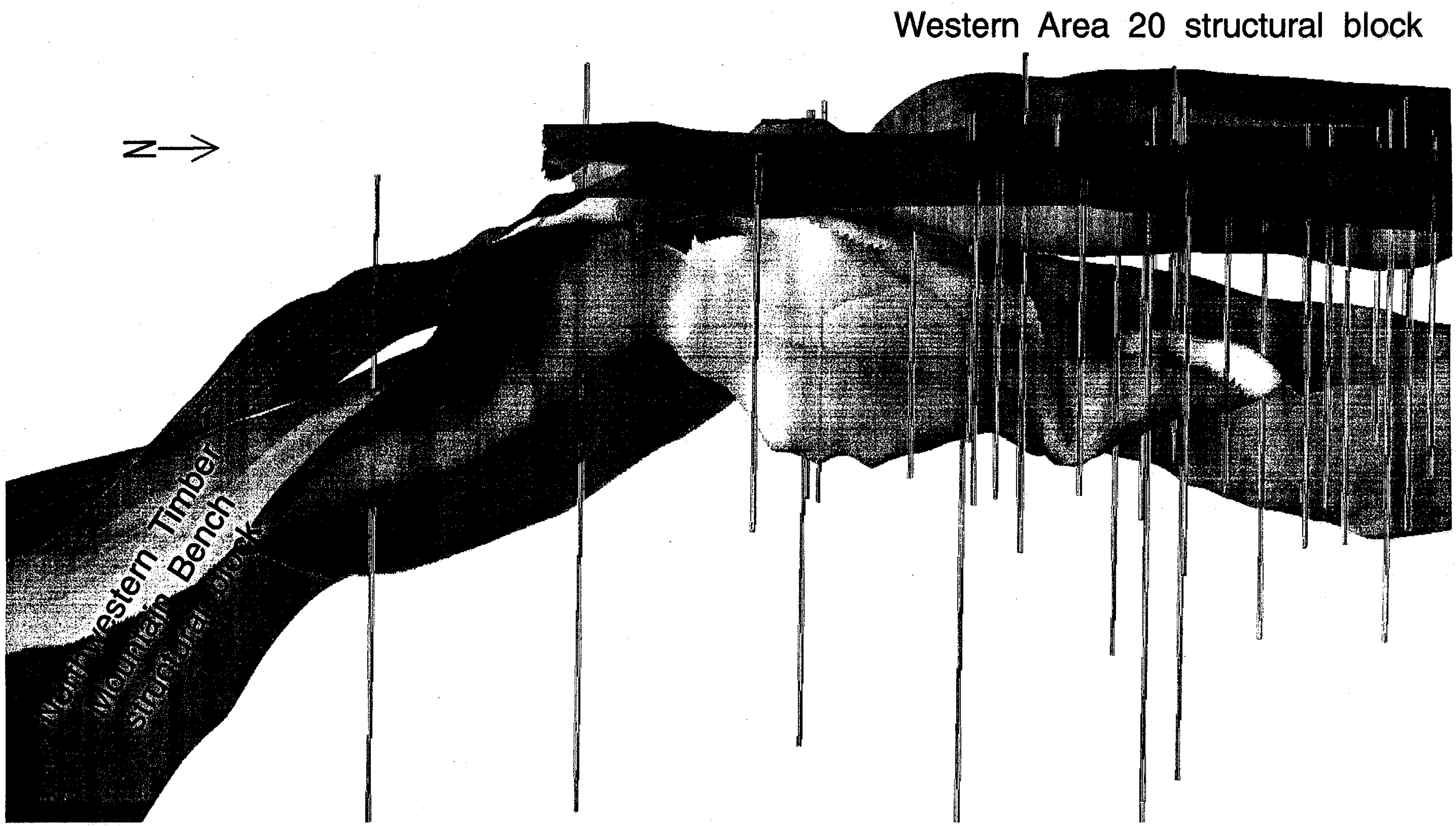

Figure 6. Three-dimensional representation in green for top surface of Rainier Mesa Tuff (Tmr), and in brown for top and bottom of Topopah Spring Tuff (Tpt), looking from east. Vertical bars show that all drill holes penetrate the top of Tmr, and most penetrate Tpt. This view graphically illustrates the dramatic decrease in elevation for each stratigraphic unit southward from the Western Area 20 structural block into the Northwestern Timber Mountain Bench block. The striking decrease may reflect a buried, west-northwest trending fault.

For example, locations or suspected locations are known for many calderas, but without drill holes, the actual lithologies are unknown. In addition to providing predictive hydraulic properties where none are available, a scheme based on structural environment provides subdivisions that seem warranted to add to existing hydrogeologic classification schemes (Drellack and Prothro, 1997; Laczniak et al.,1996; Winograd and Thordarson, 1975). For example, it might be expected that the welded-tuff aquifer of a thick, intracaldera sequence might differ markedly in hydraulic character from that of a thin outflow sheet.

Virtually the entire sequence of volcanic units of the SWNVF was erupted from calderas, and may be generalized into three distinctive groups. *Intracaldera units* are invariably very thick ash-flow tuffs, intercalated with breccia near caldera margins, and generally strongly *welded* and devitrified, but in at least one case *nonwelded* and zeolitic. *Extracaldera units*, the generally much thinner equivalents of *intracaldera units*, are not associated with porous breccia, and also come in two varieties, *welded* and *nonwelded*. *Near-caldera units* are sequences of lavas and associated tuffs that precede, fill, overflow, and erupt near calderas. *Near-caldera units* are either volatile-poor, mostly lava with little associated tuff, termed *lava-flow* hydrogeologic unit, or volatile-rich, lava with much associated tuff, termed *tuff-cone* hydrogeologic unit. Eruption of tuff generally precedes lava of the *tuff-cone* unit, forming a tuff cone that is partly to entirely filled and often breached by the successor lava. In many cases, a *tuff-cone* unit is composed of a stack of successive tuff-cone and lava pairs. Each of the three general types of volcanic hydrogeologic units has two varieties, for a total of six volcanic hydrogeologic units for the SWNVF, as summarized in Table 6 and described in Figures 7 to 9.

Table 6. Association of hydrogeologic units with structural environment

Structural designation for stratigraphic unit is specific for each structural block. For example, Timber Mountain Group (Tm) is intracaldera in Central Timber Bench structural block but extracaldera in Southern Split Ridge block. Alterations are generalized below static water level (SWL). For type of hydrogeologic unit, see discussion below.
Lithologies are: WT = welded tuff; NWT = nonwelded tuff; L = lava; TB = tuff (or flow) breccia.
Alterations are: D = devitrified; Z = zeolitic.
Stratigraphic units are: Tm = Timber Mountain Group; Tcbl = Lithic-rich Bullfrog Tuff; Tci = rhyolite of Inlet; Th = Calico Hills Formation; Tp = Paintbrush Group.

Structural environment	**Lithology**	**Alt**	**Hydrogeologic unit**			**Strat unit**	**Structural block**
			sym	name	flow		
intracaldera	WT	D	IW	intracaldera welded tuff	pipe and sheet	Tm	Central Timber Bench
	lithic-rich NWT	Z	IN	intracaldera nonwelded tuff	pipe	Tcbl	Eastern Area 20
near-caldera	L	D	LF	lava-flow	sheet and pipe	Tci	Southern Area 19
	L,NWT,TB	D,Z	TC	tuff-cone	pipe	Th	Central Area 19
extracaldera	WT	D	EW	extracaldera welded tuff	sheet	Tp	Western Area 20
	NWT	Z	EN	extracaldera nonwelded tuff		Th	Kawich Canyon

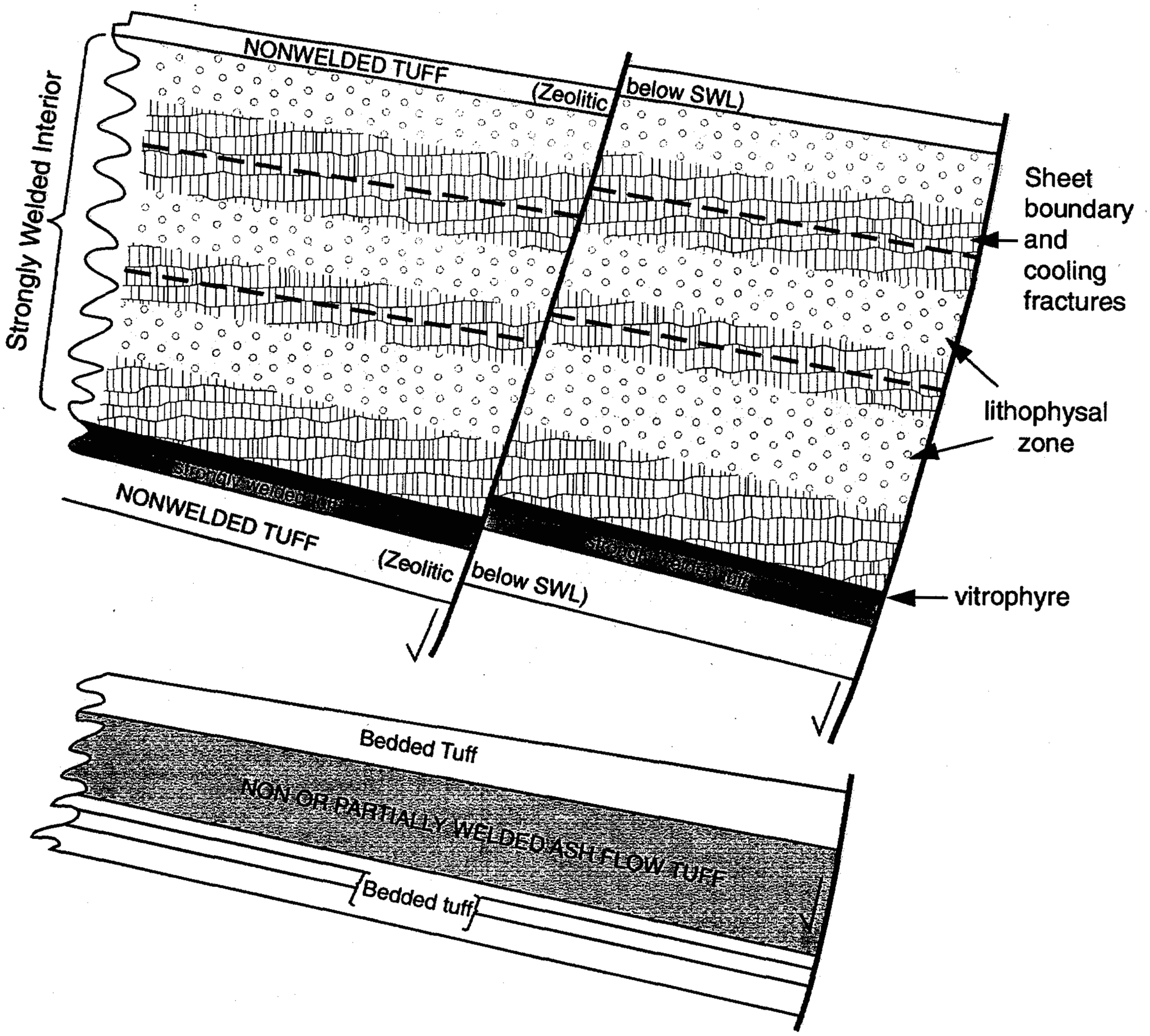

Figure 7. Schematic cross section illustrating idealized hydrogeology of extracaldera units. The upper diagram illustrates thick extracaldera welded tuff, presumed to be erupted in several stages, each separated by a short time interval, and each stage erupting a separate "sheet". Dashed lines represent boundaries between sheets. Extracaldera welded tuffs generally consist of a thick, strongly (moderately to densely) welded interior, a basal vitrophyre, and a thin layer of strongly welded tuff beneath the vitrophyre, all sandwiched between nonwelded tuff. Upper and rarely medial vitrophyres may be developed at the base of each sheet. Locally, the basal part of the sequence may not develop where the extracaldera welded tuff has an intermediate thickness, as for Rainier Mesa Tuff in U20AP (Warren et al., 2000). Erosion of extracaldera tuffs in the SWNVF is minor, so tops are generally well preserved. Examples are the Rainier Mesa Tuff of Pahute Mesa (Ferguson et al., 1994) and the Topopah Spring Tuff of Yucca Mountain (Spengler et al., 1984). Cooling fractures develop most strongly at the top and base of each sheet; lithophysal zones occur between.

Hydraulic flow occurs almost entirely within cooling fractures in the strongly welded interior of extracaldera welded tuff. Thus hydraulic flow should occur in sheetlike fashion. Lithophysal zones between fractured zones are not strongly fractured, and fractures are short, generally only connecting between lithophysae. Because cooling fractures are lengthy, minor faults should not generally disrupt flow paths. Thin extracaldera welded tuff cools as a single unit, even if composed of more than a single sheet (e.g., Tiva Canyon Tuff of Pahute Mesa), and lithophysal zones are seldom observed and poorly developed if present. Therefore thin extracaldera welded tuff can be considered hydrogeologically as a thin, tabular set of hydraulically conductive cooling joints. Due to its thinness, minor faults may disrupt flow paths.

The lower diagram shows a typical sequence of extracaldera nonwelded tuff. Below the static water level (SWL), extracaldera nonwelded tuff invariably includes zeolitic (or potassic) bedded and reworked tuff, and thin to thick nonwelded ash flow tuff, all which have very low matrix permeability. Also included within the extracaldera nonwelded tuff hydrogeologic unit is partially welded (generally vapor phase) ash flow tuff, which probably has a considerably higher matrix permeability than zeolitic tuffs. Cooling fractures do not occur within the zeolitic tuffs, and are poorly developed within partially welded ash flow tuff, so hydraulic pathways are defined almost entirely by regional fractures (faults and joints).

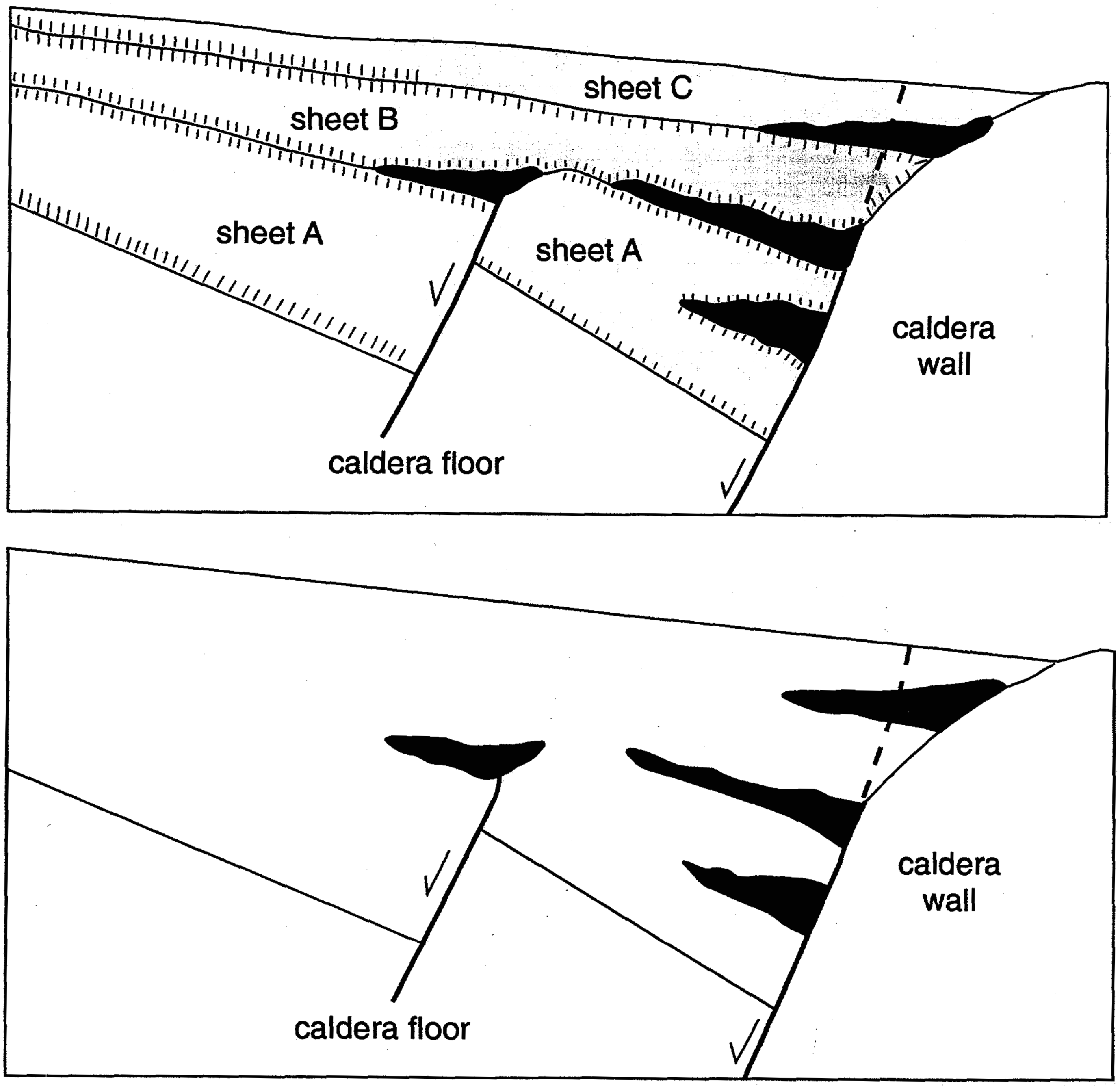

Figure 8. Schematic cross section illustrating idealized hydrogeology of intracaldera units. The upper diagram illustrates intracaldera welded tuff, presumed to be erupted in several stages, each separated by a short time interval, and each stage producing a separate "sheet" that should promote sheetlike hydraulic flow. Examples are the Ammonia Tanks and Rainier Mesa Tuffs of the Timber Mountain caldera. Cooling fractures should develop in much the same manner as for thick extracaldera welded tuffs (Figure 7). In addition, cold wall rock intercalated within the tuff by sliding off caldera walls, and from intracaldera structures activated during caldera formation, forms debris lenses that provide very permeable, pipelike hydraulic paths. Finally, intense structural activity is expected from the catastrophic nature of caldera collapse, leading to a much increased density of faults and fractures for intracaldera tuff compared to extracaldera tuff. Although the factors described above suggest a hydraulically very conductive medium, many calderas are associated with intense post-collapse hydrothermal alteration that may seal up all hydraulically conductive paths. UE18R, which penetrates intracaldera Rainier Mesa and Ammonia Tanks Tuffs, does not indicate widespread intense hydrothermal alteration within the Timber Mountain caldera. But UE19W1, near the boundary of the Area 20 caldera, exhibits extreme hydrothermal alteration, indicating that hydrothermal alteration may locally "seal up" a caldera.

The lower diagram shows that separate sheets are not recognizable in intracaldera nonwelded tuff, and only the debris lenses and increased density of faults and fractures would seem to provide hydraulically conductive, pipelike pathways. An example is the lithic-rich Bullfrog Tuff of the Area 20 caldera.

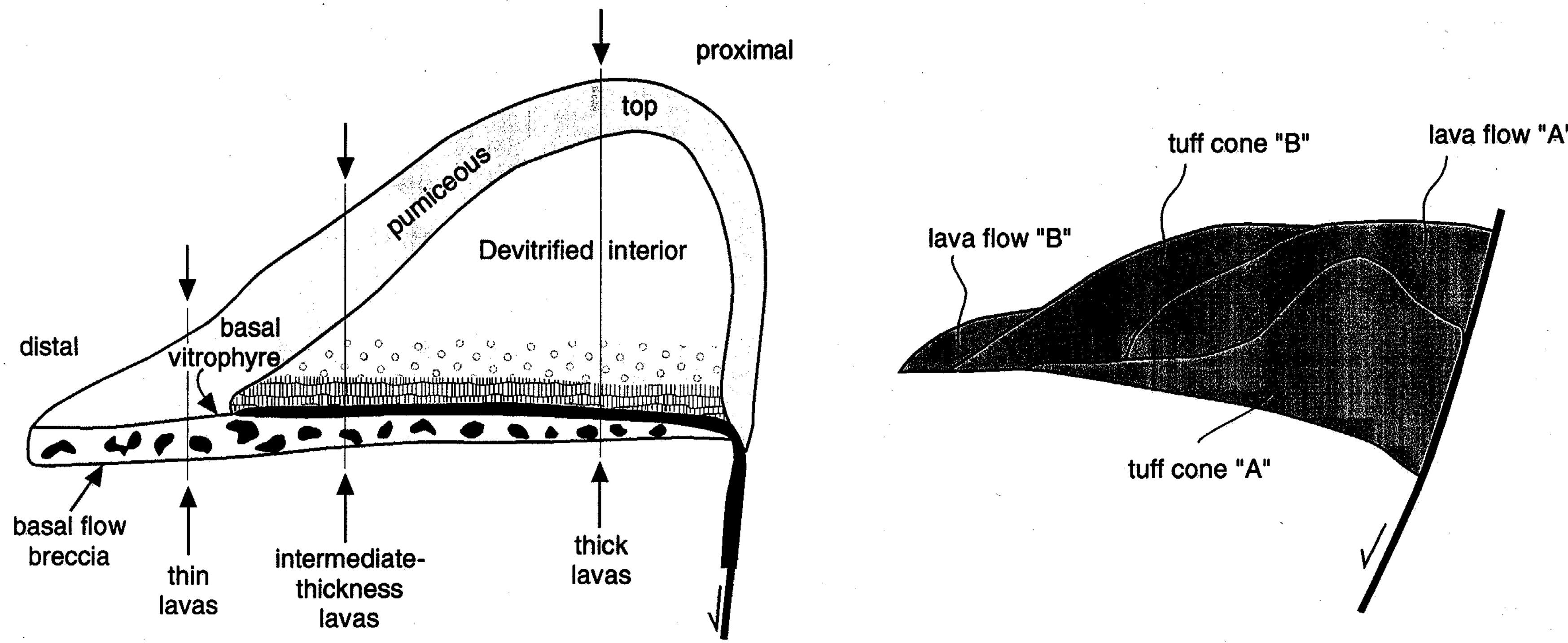

Figure 9. Schematic cross section illustrating idealized hydrogeology of near-caldera units. The left diagram illustrates a thick lava-flow hydrogeologic unit such as rhyolite of Inlet. The lava-flow unit is typically associated with little precursor tephra, and consists of a basal flow breccia, overlying dense, glassy, basal vitrophyre, devitrified interior, and pumiceous (frothy) top. The devitrified interior occurs proximal to the vent, where the lava is thickest, and generally completely disappears in distal parts of the lava-flow unit. Thin lava flows are zoned like distal portions of thick flows, and lava flows of intermediate thickness are zoned like portions of thick lava flows at intermediate distances from the vent; arrows denote zonation for the thickest parts of such flows. Like extracaldera welded tuff, cooling joints are well developed near the base of the lava-flow unit, and overlain by a lithophysal zone. Below the SWL, the pumiceous top may be vitric, zeolitic, or partly vitric, partly zeolitic. Basal flow breccias and the fractured base of the devitrified interior are typically very permeable media, and should provide preferred hydraulic flow paths within the lava-flow hydrogeologic unit. Pumiceous tops grade inward from about 40% porosity to about 20% at the interface with devitrified interior, and so when they are vitric or partly vitric, pumiceous tops probably have good unrestricted hydraulic conductivity, entirely through matrix permeability. Unlike nonwelded tuffs, which have similar physical characteristics, pumiceous lavas are commonly vitric well below the SWL and so generally may be hydraulically conductive down to depths below which they are very likely to be entirely zeolitic, perhaps a few hundred meters below the SWL. Lava-flow units may be bulbous like rhyolite of Inlet, as illustrated, or may be nearly tabular, like rhyolite of Echo Peak, but alteration zones are always developed as shown. Hydraulic flow may be sheetlike, pipelike, or have characteristics between these types of flow, depending on the geometry and detailed lithology of the unit.

The right diagram illustrates the complex nature of the tuff-cone unit, commonly found in Pahute Mesa subsurface. Rhyolite of Fluorspar Canyon, lavas of the Paintbrush Group, and the Calico Hills Formation are examples of this hydrogeologic unit. Tuff-cone units are lavas associated with relatively large-volume precursor hydrovolcanic eruptions that typically form tuff cones or half-cones prior to eruption of lava. The lava then fills, breaches, and overflows the tuff cone as shown. Several individual tuff cones may be stacked atop each other within the Calico Hills Formation. The schematic right diagram illustrates a stack of two individual tuff-halfcone complexes. The younger complex was erupted along the same fault, behind the plane of the page.

Each lava flow within the tuff-cone unit complex is zoned like the lava-flow hydrogeologic unit shown in the left diagram. Most typically, individual lava flows have thin to intermediate thicknesses. Individual tuff cones represent bedded tuff very close to its vent, so that the tuff is invariably zeolitic rather than vitric. Consequently the tuff-cone hydrogeologic unit is composed of hydraulically conductive lenses of lava and hydraulically confining lenses of tuff, arranged in an unpredictable manner. It seems that the tuff-cone hydrogeologic unit might behave as an aquifer in some areas, and as a confining unit in others, and probably is more pipelike in its hydraulic behavior than the lava-flow hydrogeologic unit.

Greatly simplified, three general types of hydraulic flow might be envisioned within volcanic rocks and alluvium of the SWNVF. The simplest type, which might occur in volcanic rocks only within vitric, massive, nonwelded tuffs, would be characterized by flow that is unrestricted in all three directions (X, Y, and Z), and therefore termed *unrestricted flow*. Such flow should characterize alluvium. The next simplest flow, *sheet flow*, would be characterized by flow that is unrestricted in two directions, but confined to a layer or zone and thus restricted in the third direction. Examples of *horizontal sheet flow* might be welded ash flow tuffs, either intracaldera or extracaldera. Faults could be considered as cases of *horizontal sheet flow*. Finally, lava flows and debris flows along caldera margins provide long, narrow conduits for flow that essentially is unidirectional, and termed *pipe flow*.

The tuff-cone aquifer is important within Western Area 20 structural block, where the Calico Hills tuff-cone aquifer is prevalent at the water table. To properly model groundwater flow, it is important to properly represent such a unit, which there consists of a spatially unpredictable assemblage of lava and zeolitic nonwelded tuff. Field observations indicate that lava within a tuff-cone aquifer, which hosts fracture-dominated hydraulic flow, occurs as an irregular lens that flows from its vent along a channel cut into underlying nonwelded tuff. In the Calico Hills tuff-cone aquifer, successive eruptions repeat the lithologic complexity, as shown in Figure 9. Hydraulic flow in a tuff-cone aquifer can be precisely modeled if each successive eruption is recognizable as a subunit. Prothro and Warren (2000) subdivided that mafic-poor Calico Hills Formation, based on detailed petrographic analyses and mineral chemistry by microprobe. In lieu of unit subdivision, a tuff-cone aquifer is best modeled using a Monte Carlo approach to construct the lithologic complexity (Weissmann et al., 1999; Carle et al., 1998).

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APPENDIX A

Contoured top elevations and isopachs for each stratigraphic unit

Note that the initial figure in Appendix A locates structural features and important drill holes within the region modeled in three dimensions. The back pocket provides this figure as an overlay, as well as a compact disk (CD) that provides each figure except the initial one in electronic form. This CD also contains a file of all structural data that were honored to produce the three dimensional model. The final figure provides contoured bottom elevations for the stratigraphically lowest unit.

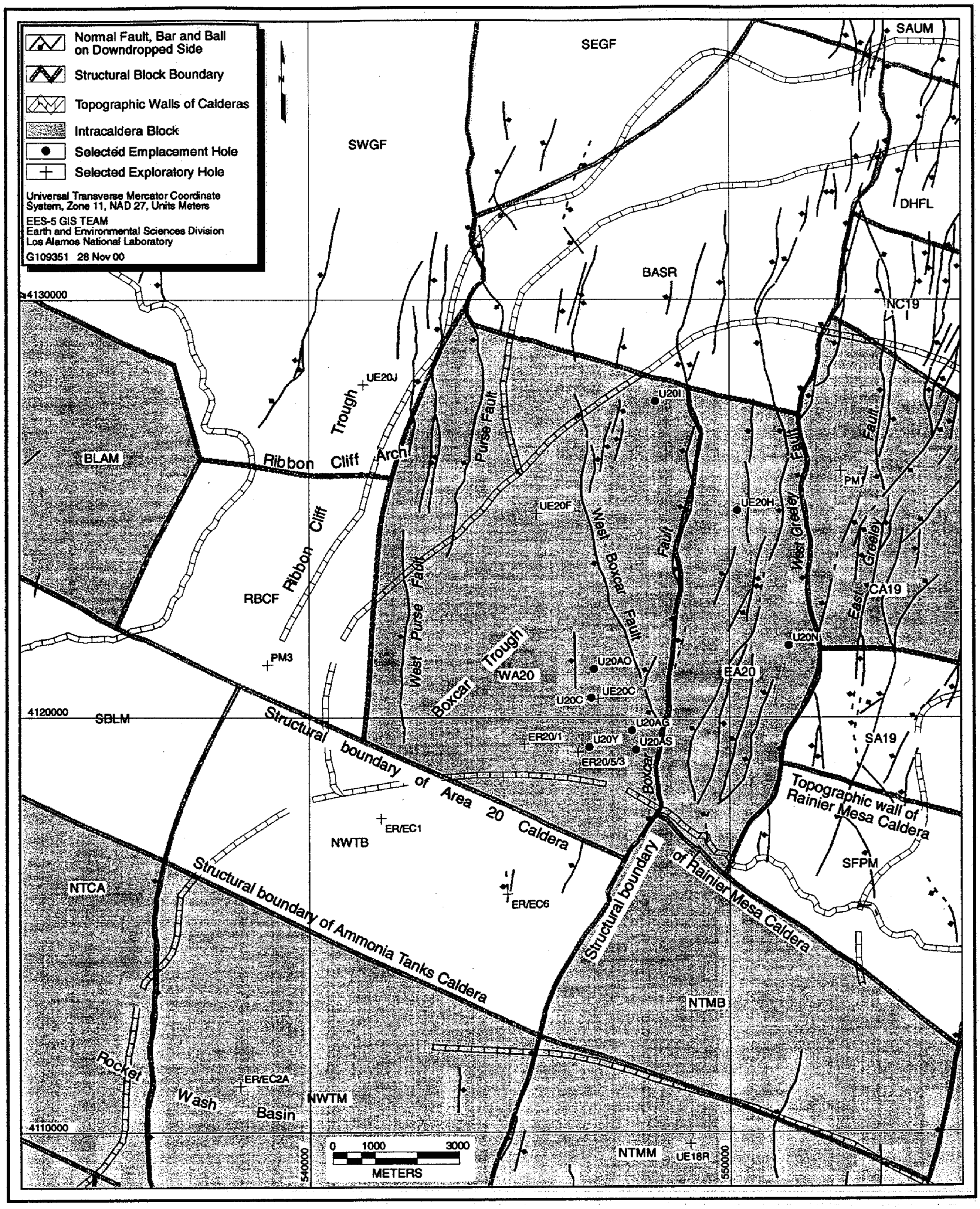

Figure A1. Structural features within the area modeled in three dimensions (Figure 1), adapted from Figure 3-1 of Prothro and Warren, 2000. Symbols for structural blocks (e.g., WA20, Western Area 20) are defined in Table 1. Back pocket provides this figure as an overlay.

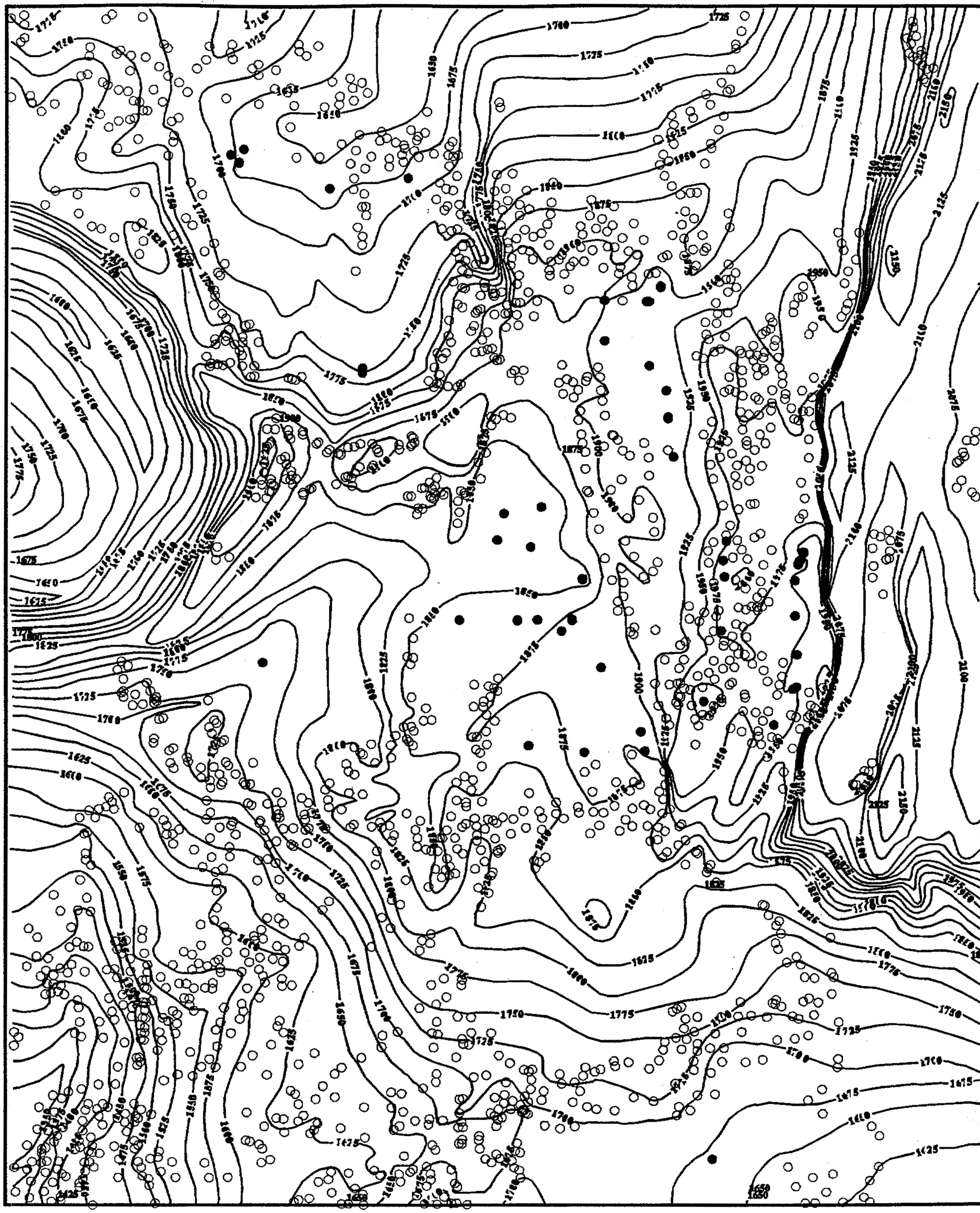

Figure A2. Model elevations for top of Pahute Mesa Tuff (Ttp) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is locally absent within a few areas, as defined in Figure 3-11 of Prothro and Warren,2000. Small circles show location of control points, which include outcrop and subsurface; filling colors define differences between observations and model: blue <1 m, green 1-3 m, yellow 3-6 m, orange 6-10 m, and red >10 m. Gray fill defines zero thickness, and no fill indicates imprecise or inappropriate data, as explained in Table 3. Displacement of Ttp is 150 m across the West Greeley fault, and 75 m across the West Boxcar fault. Other prominent structural features are the western half of the Rocket Wash basin, with 250 m of structural relief, the Ribbon Cliff trough, with 150 m of relief, the Ribbon Cliff arch, with 75 m of relief, and the topographic wall of Rainier Mesa caldera, with 300 m of relief. Structural relief within Black Mountain caldera is unconstrained and conjectural.

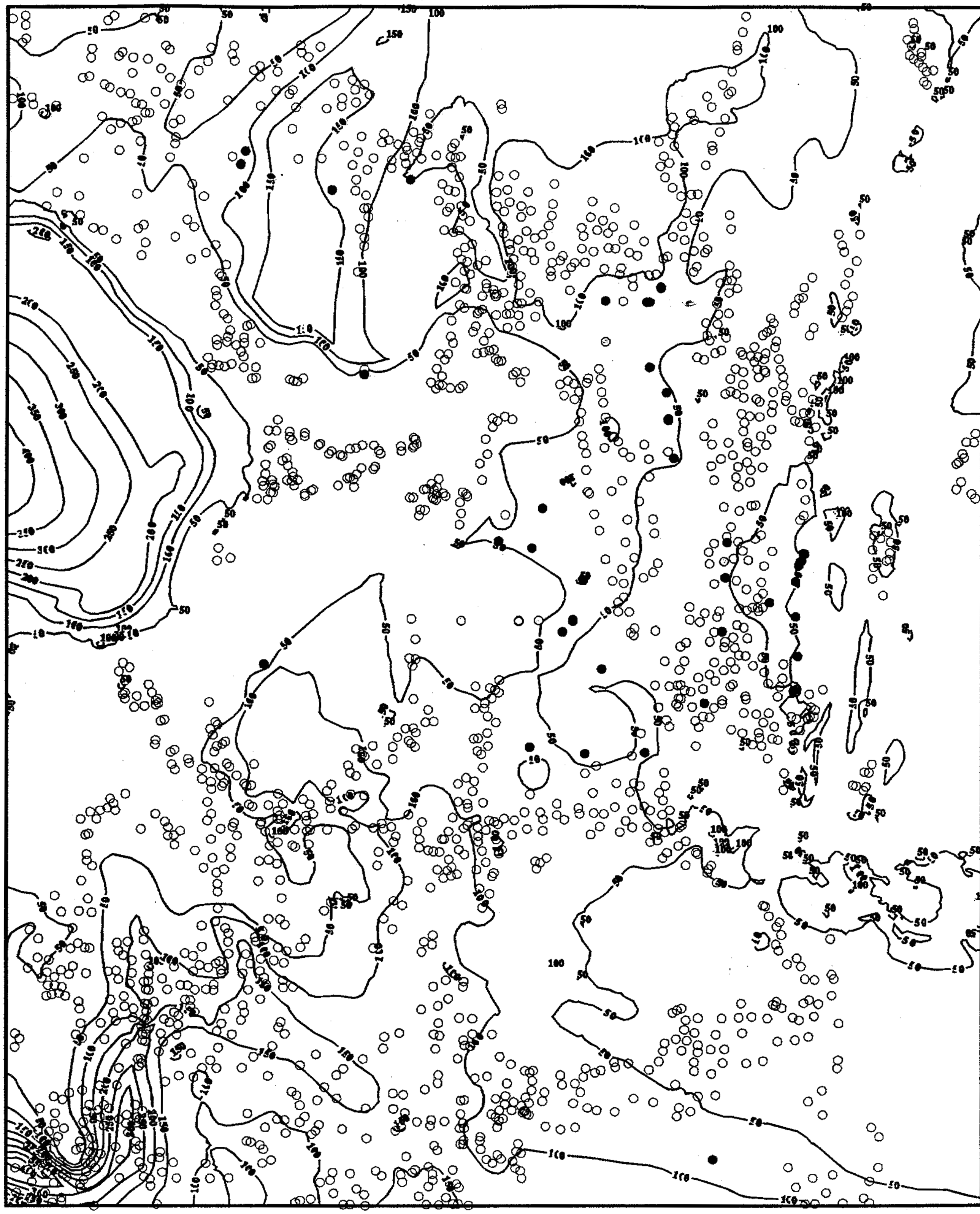

Figure A3. Model isopachs for combined Pahute Mesa Tuff (Ttp) and Rocket Wash Tuff (Ttr) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is known to be locally absent within a few areas, as defined in Figure 3-11 of Prothro et al. (2000). Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Thicknesses represent differences between top of Ttp and underlying unit. The Rocket Wash basin is a prominent structural feature with a calculated, combined thickness of 400 m for Ttp and Ttr in its western half. These great thicknesses are corroborated by ER/EC4 (Table 1), near the western edge of the Rocket Wash basin but just outside the map area. Thicknesses of Ttp and all older units within Black Mountain caldera are unconstrained and conjectural.

Figure A4. Model elevations for top of comendite of Ribbon Cliff (Ttc) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

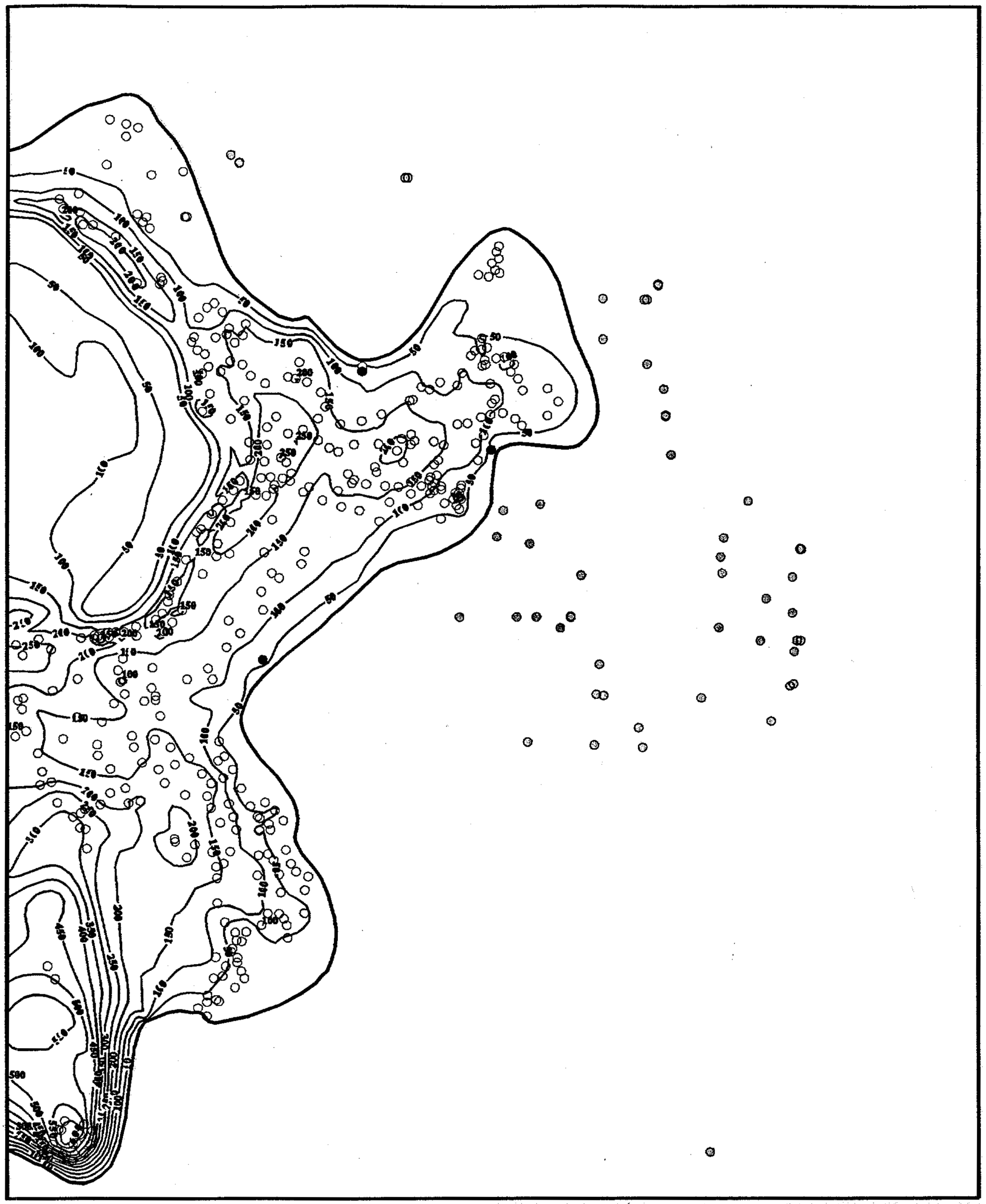

Figure A5. Model isopachs for comendite of Ribbon Cliff (Ttc) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. The western half of the Rocket Wash basin is a prominent structural feature with a calculated thickness of 600 m for Ttc.

Figure A6. Model elevations for top of Beatty Wash Formation (Tfb) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Elevations for Tfb define a structure that divides the Rocket Wash basin into western and eastern halves. These elevations are controlled by ER/EC4 (Table 1), near the western edge of this basin but just outside the map area.

Figure A7. Model isopachs for Beatty Wash Formation (Tfb) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. The eastern half of the Rocket Wash basin is a prominent structural feature with a thickness of >924 m for Tfb in drill hole ER/EC2A.

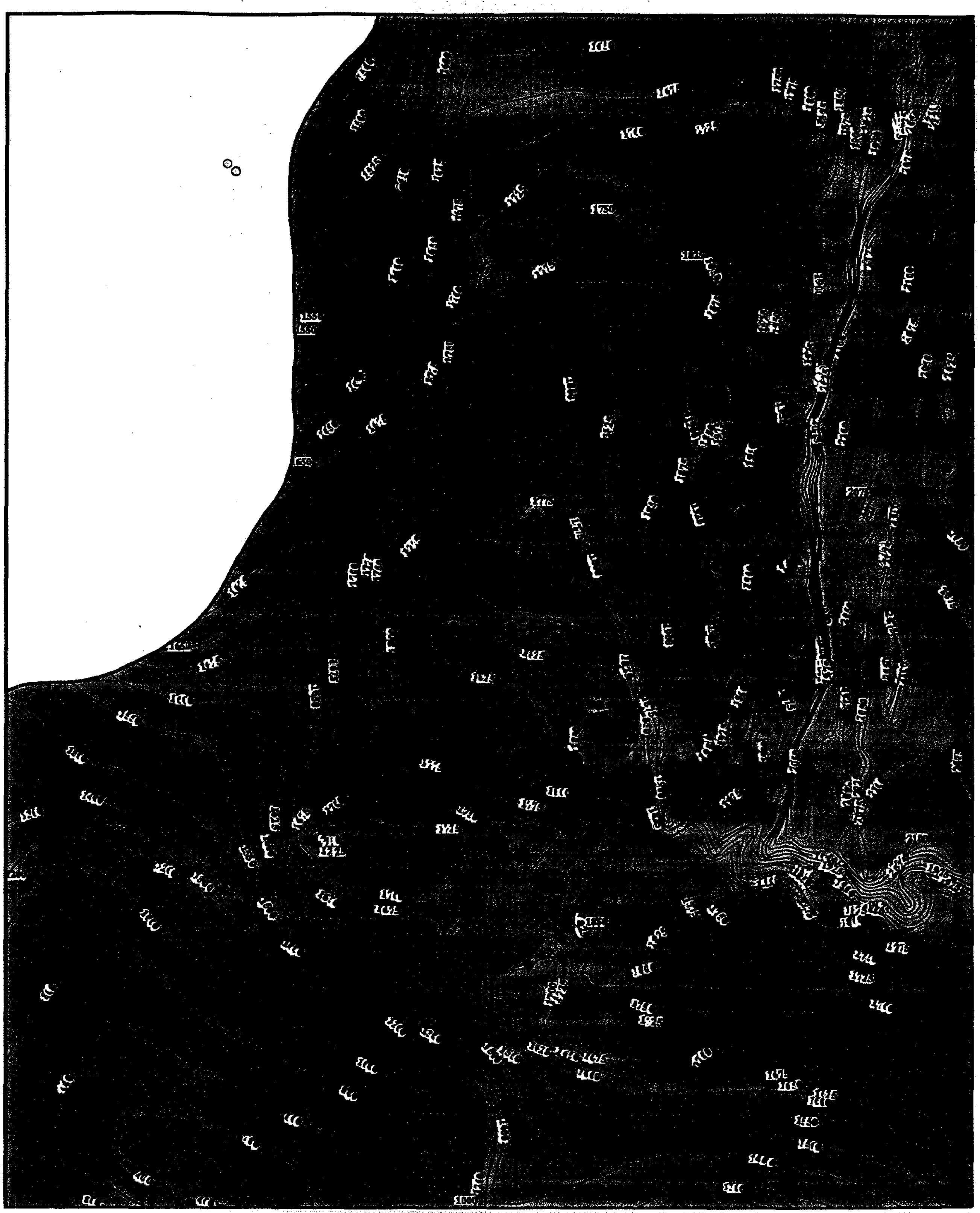

Figure A8. Model elevations for top of Ammonia Tanks Tuff (Tma) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region, and is locally absent within a few areas, as defined in Figure 3-12 of Prothro and Warren, 2000. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Displacement of Tma is 200 m across the West Greeley fault, and 100 m across the West Boxcar fault. Sparse control by ER/EC4 and ER/EC2A (Table 1) do not mandate a structural division of the Rocket Wash basin into western and eastern halves.

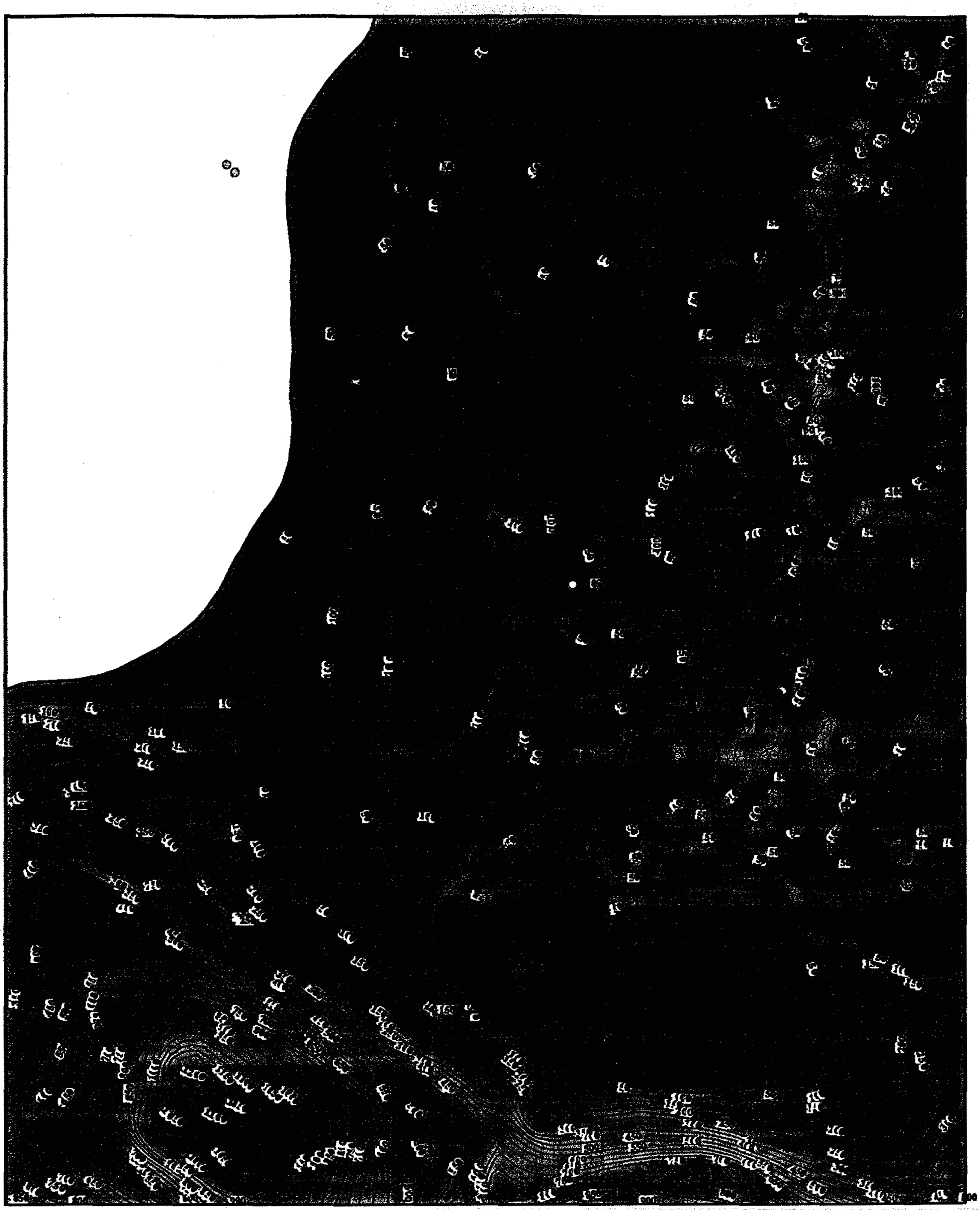

Figure A9. Model isopachs for Ammonia Tanks Tuff (Tma) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. The Rocket Wash basin is a prominent structural feature with a thickness of >553 m for Tma in drill hole ER/EC2A. Here the unit consists of uppermost, mafic-rich Tma at the bottom of the hole, overlain by "regurgitants" such as tuff of Buttonhook Wash (R. G. Warren, unpublished petrographic analyses).

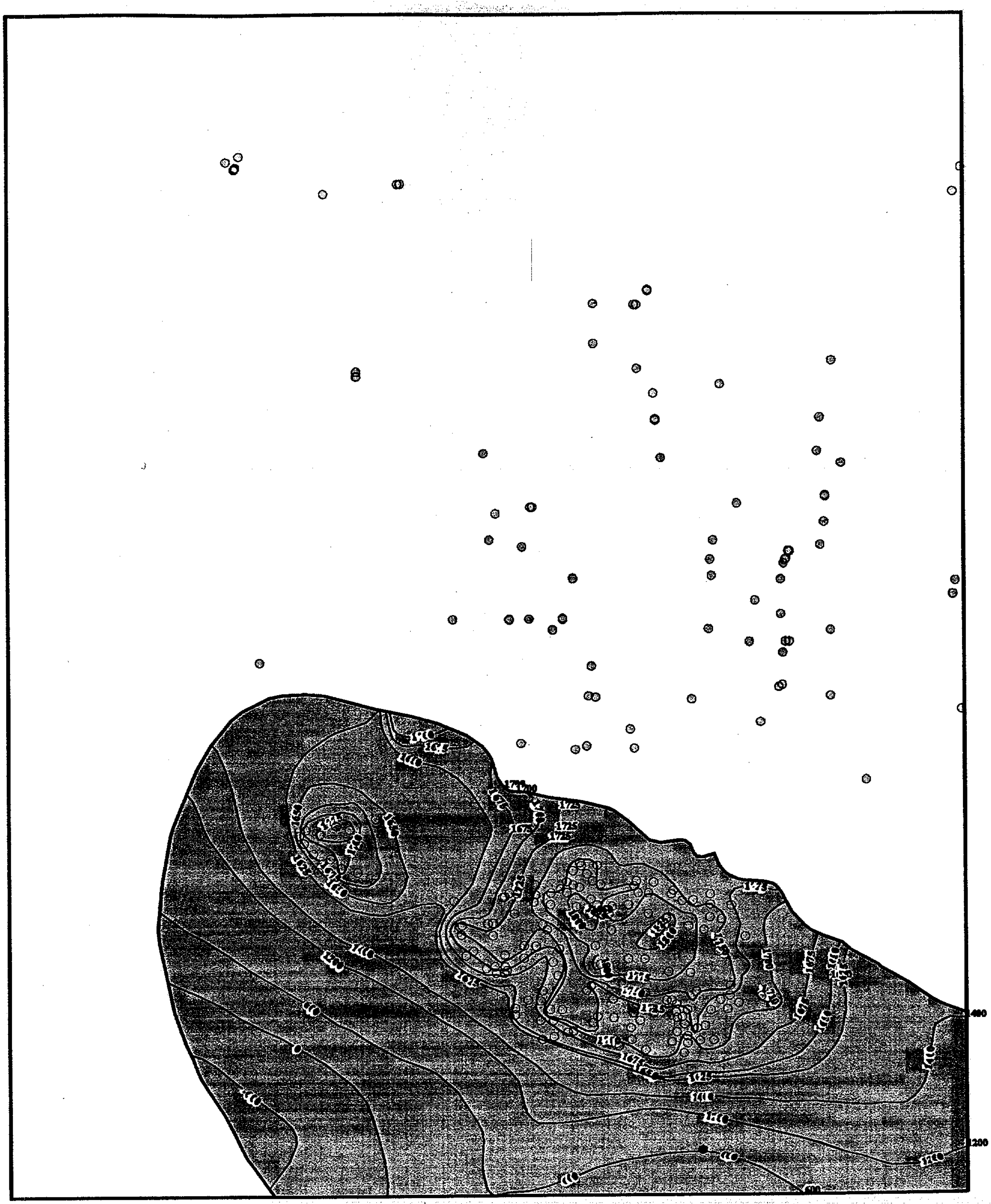

Figure A10. Model elevations for top of rhyolite of Tannenbaum Hill (Tmat) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Outcrop almost exclusively provides control where the unit apparently is thickest. Unit is absent outside contoured region, although bedded, lower portion of overlying Tma probably represents distal portion of Tmat. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

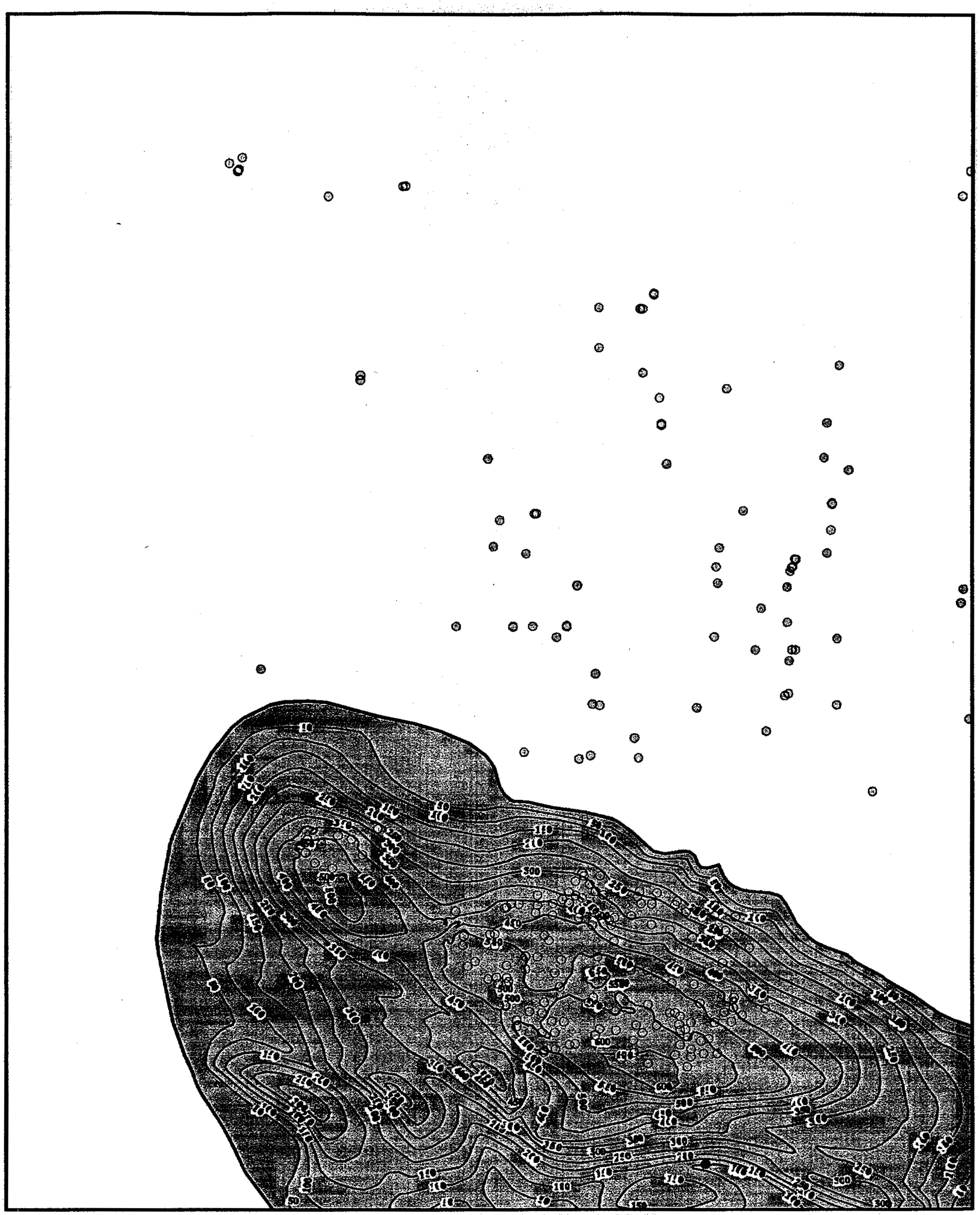

Figure A11. Model isopachs for rhyolite of Tannenbaum Hill (Tmat) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. The striking confinement of Tmat to the Northwestern Timber Mountain Bench structural block indicates the existence of a structural barrier during its eruption to its northward spread into the adjacent Western Area 20 structural block. Such a barrier is not evident for isopachs of the older rhyolite of Benham, indicating episodic activity along this northwest trending structure, which is clearly evident for even older units such as Tiva Canyon Tuff and Topopah Spring Tuff. This structure appears to have served as structural boundary of the Area 20 caldera, with displacement in the opposite sense. Only ER/EC1 and ER/EC6 provide control where the unit is apparently thickest (Table 1), and thicknesses of Tmat and all older units within Rocket Wash basin are unconstrained and conjectural.

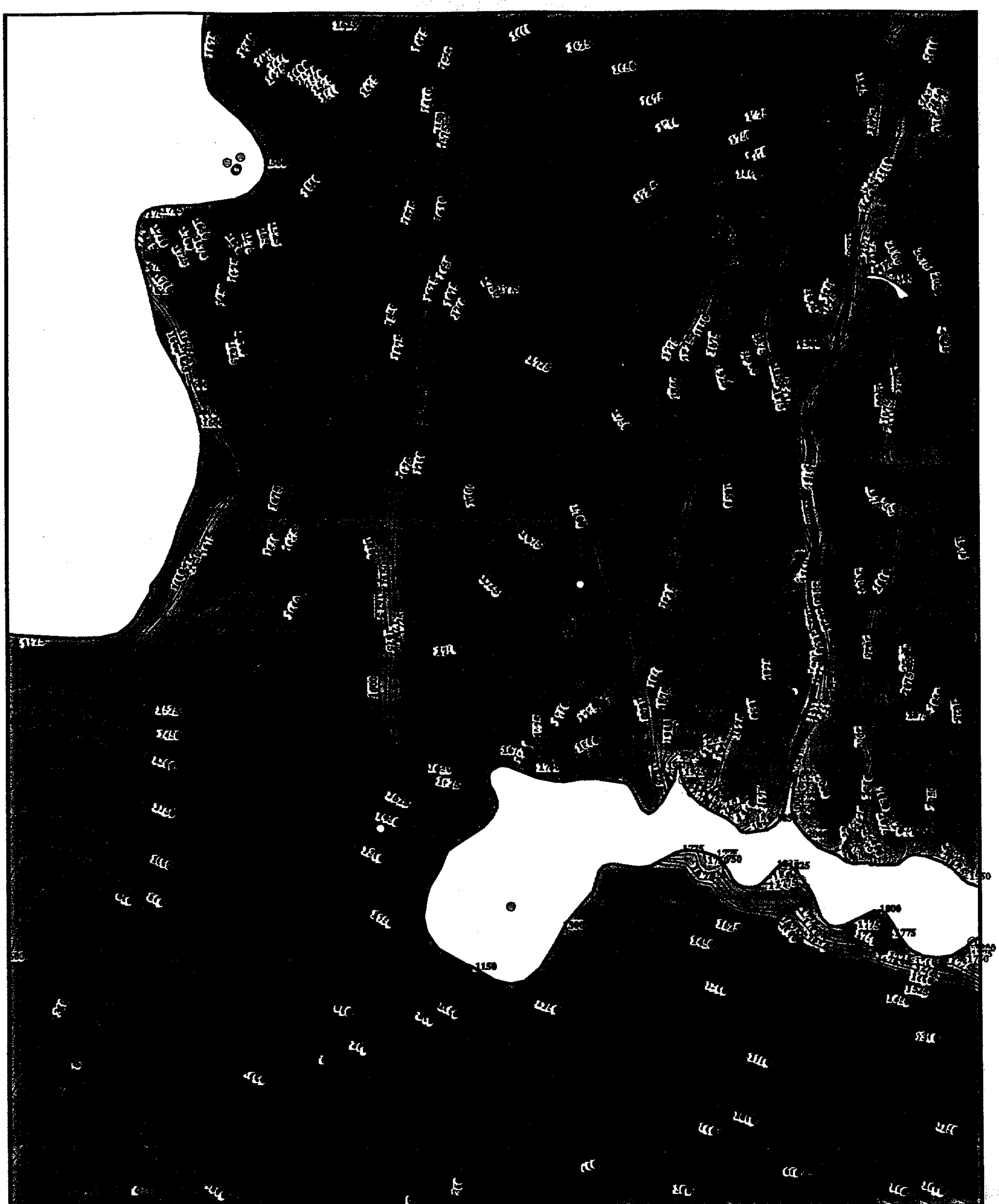

Figure A12. Model elevations for top of Rainier Mesa Tuff (Tmr) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region, and is locally absent within a few areas, as defined in Figure 3-9 of Prothro and Warren, 2000. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Displacement of Tmr is 225 m across the West Greeley fault, 175 m across the West Boxcar fault, and several hundred meters across the topographic wall of Rainier Mesa caldera, indicating that this feature also represents a major structural feature.

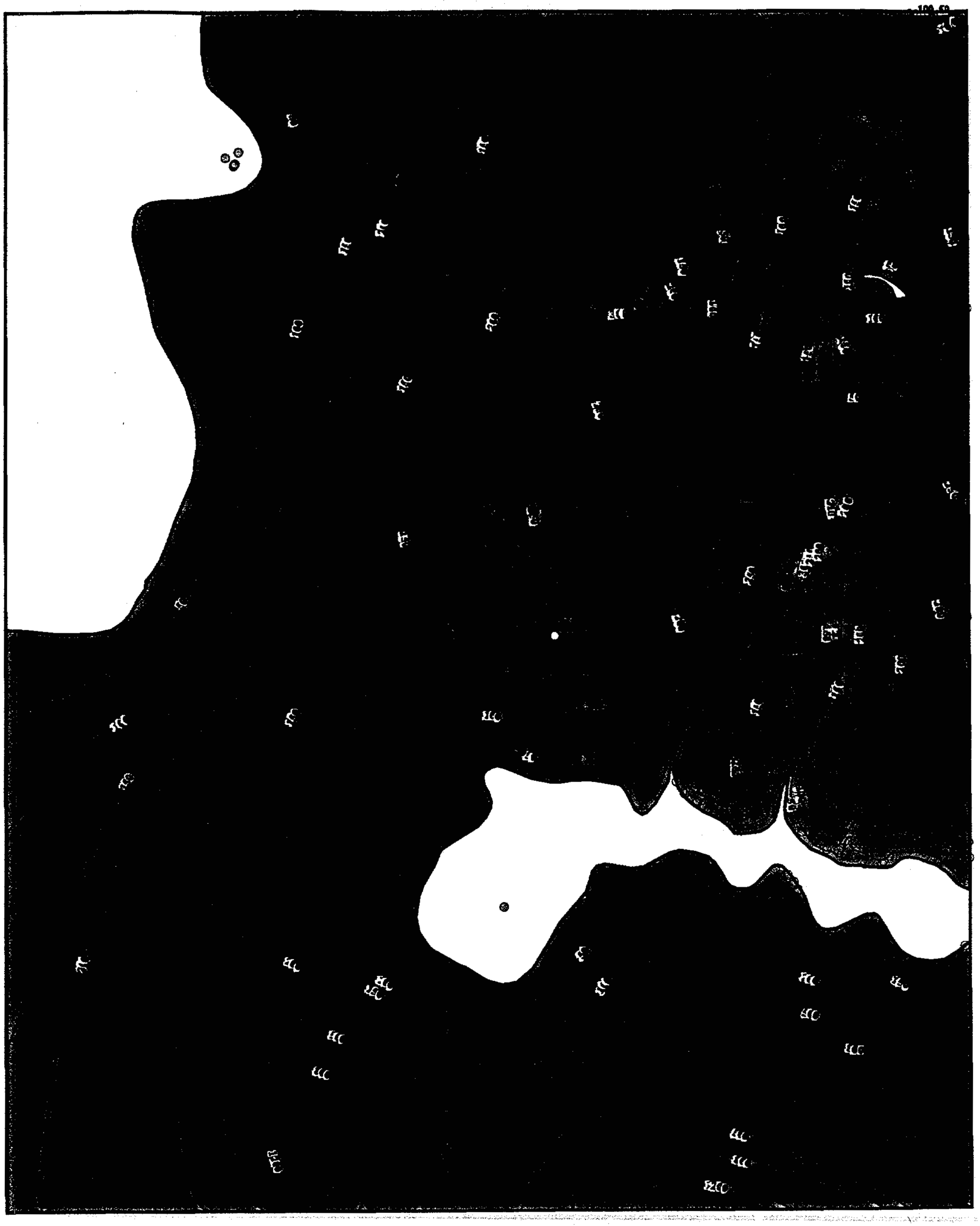

Figure A13. Model isopachs for Rainier Mesa Tuff (Tmr) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

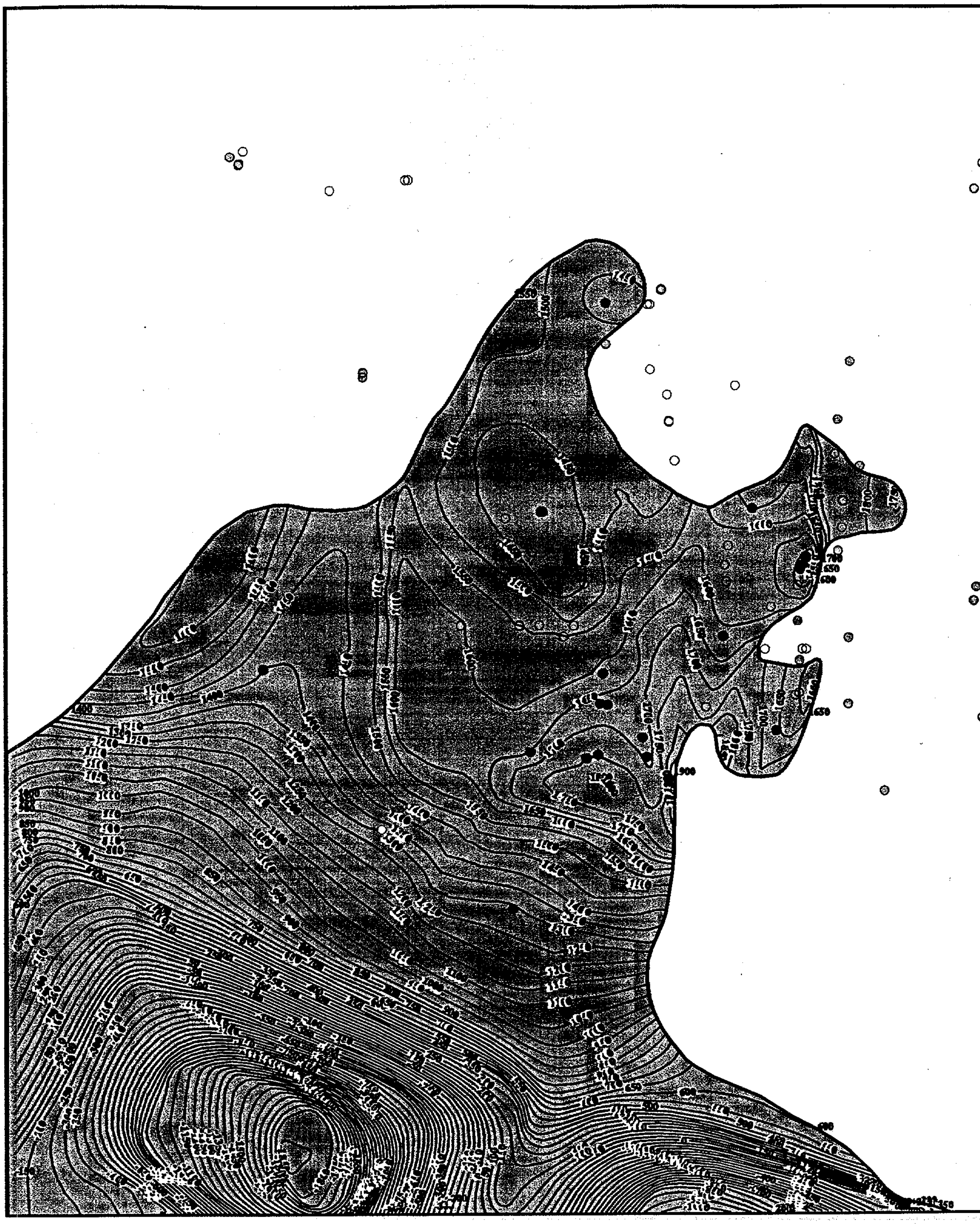

Figure A14. Model elevations for top of rhyolite of Fluorspar Canyon (Tmrf) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

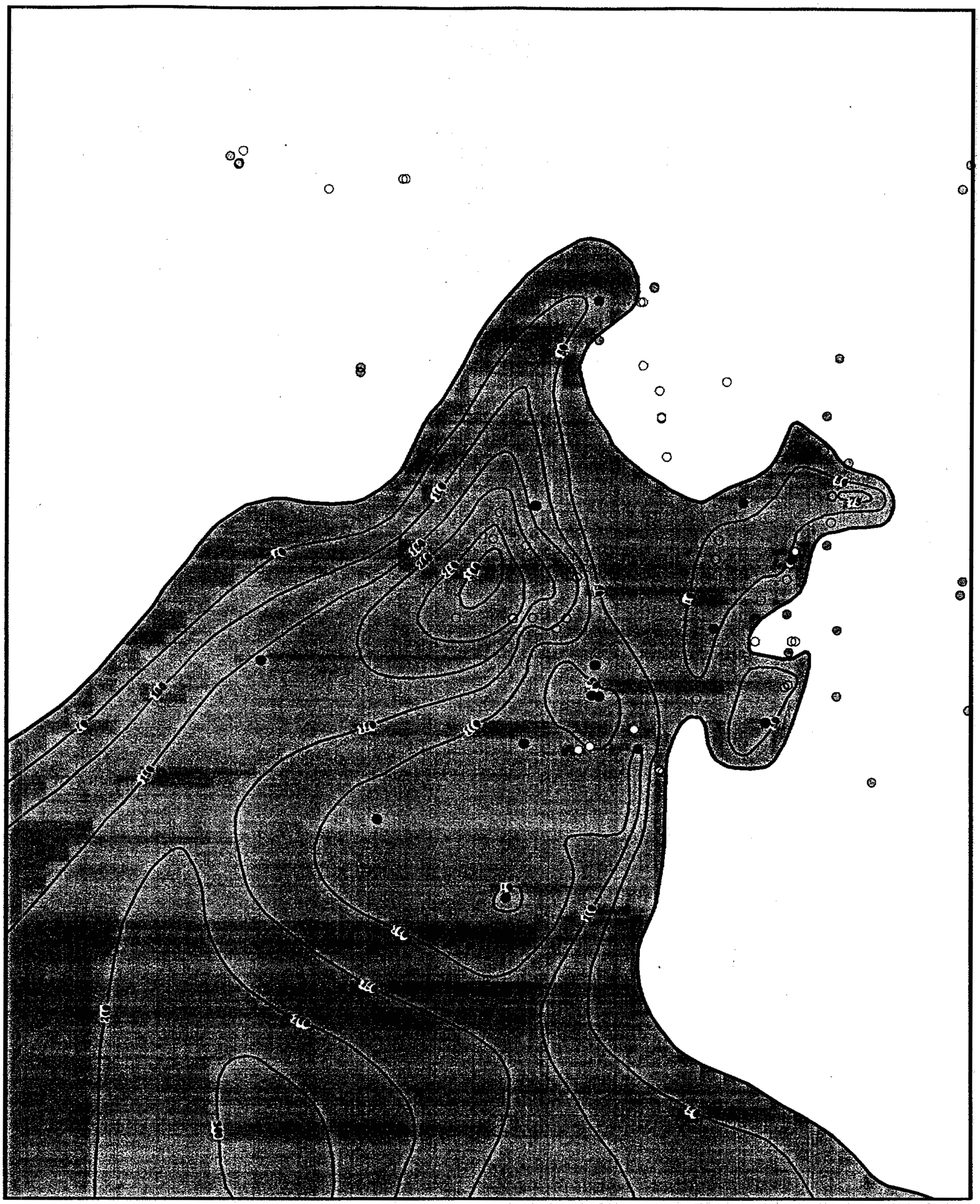

Figure A15. Model isopachs for rhyolite of Fluorspar Canyon (Tmrf) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Like overlying Tmr, Tmrf is thick within the Boxcar Trough, which suggests episodic eastward rotation of the Western Area 20 structural block along the West Boxcar fault.

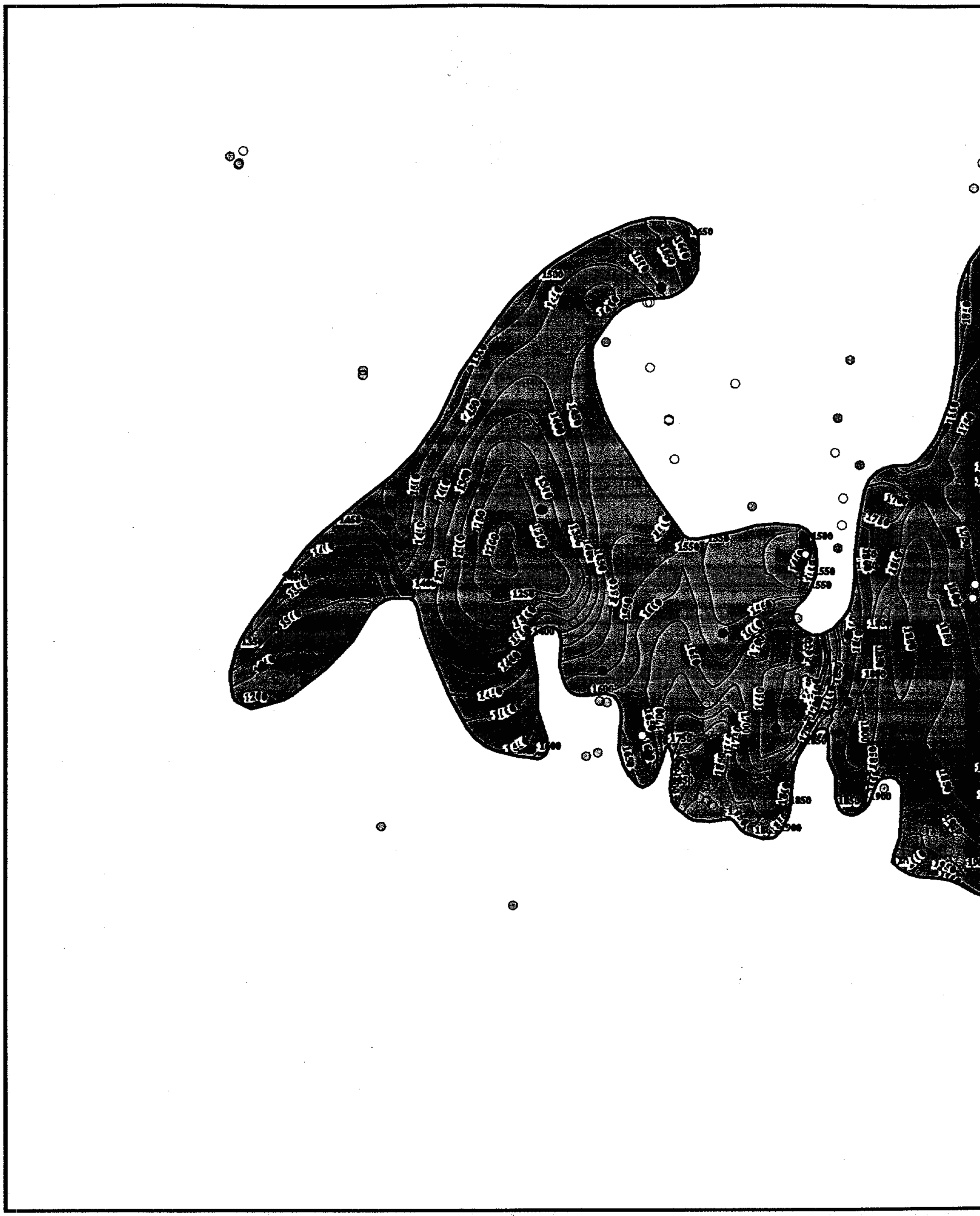

Figure A16. Model elevations for top of tuff of Holmes Road (Tmrh) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Note that the southwestern arm instead represents basalt of Tierra (Tmt) in drill hole PM3; elsewhere, these structural data indicate that Tmrh represents sediments shed northward from topographically high areas that coincide with the younger Timber Mountain caldera.

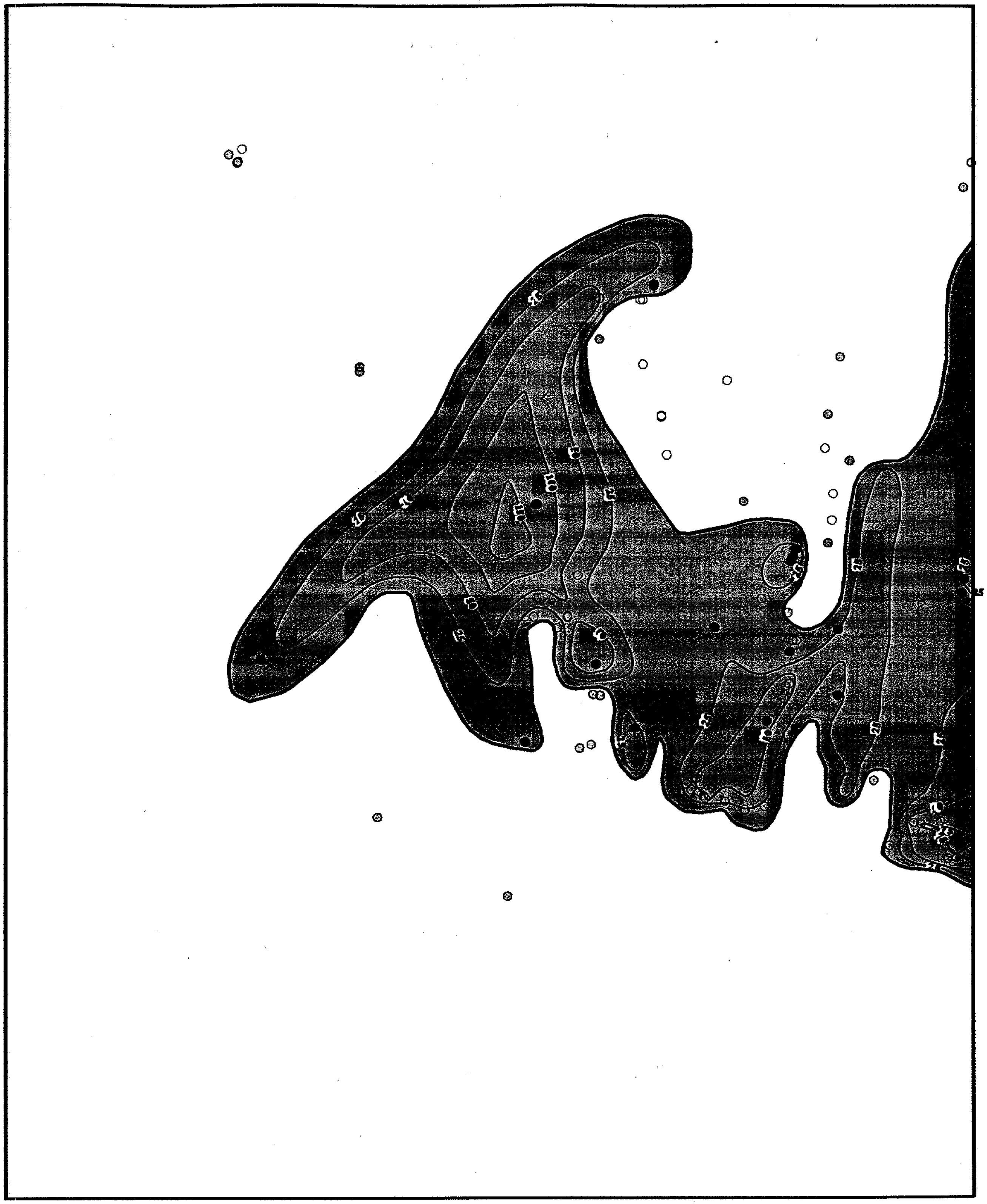

Figure A17. Model isopachs for tuff of Holmes Road (Tmrh) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. The thickest Tmrh known within the SWNVF occurs within the Boxcar Trough, where overlying Tmrf and Tmr are also thick.

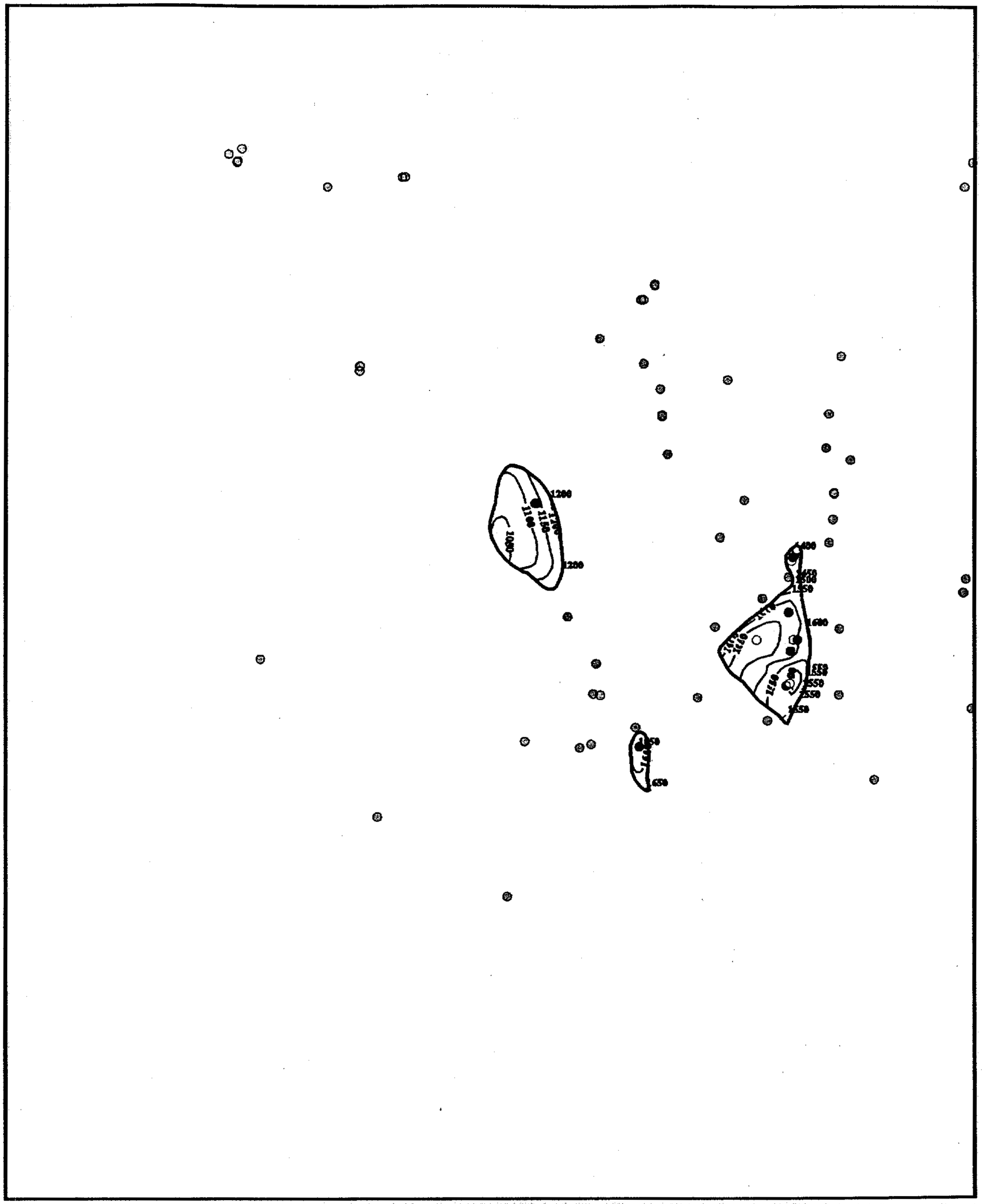

Figure A18. Model elevations for top of rhyolite of Windy Wash (Tmw) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

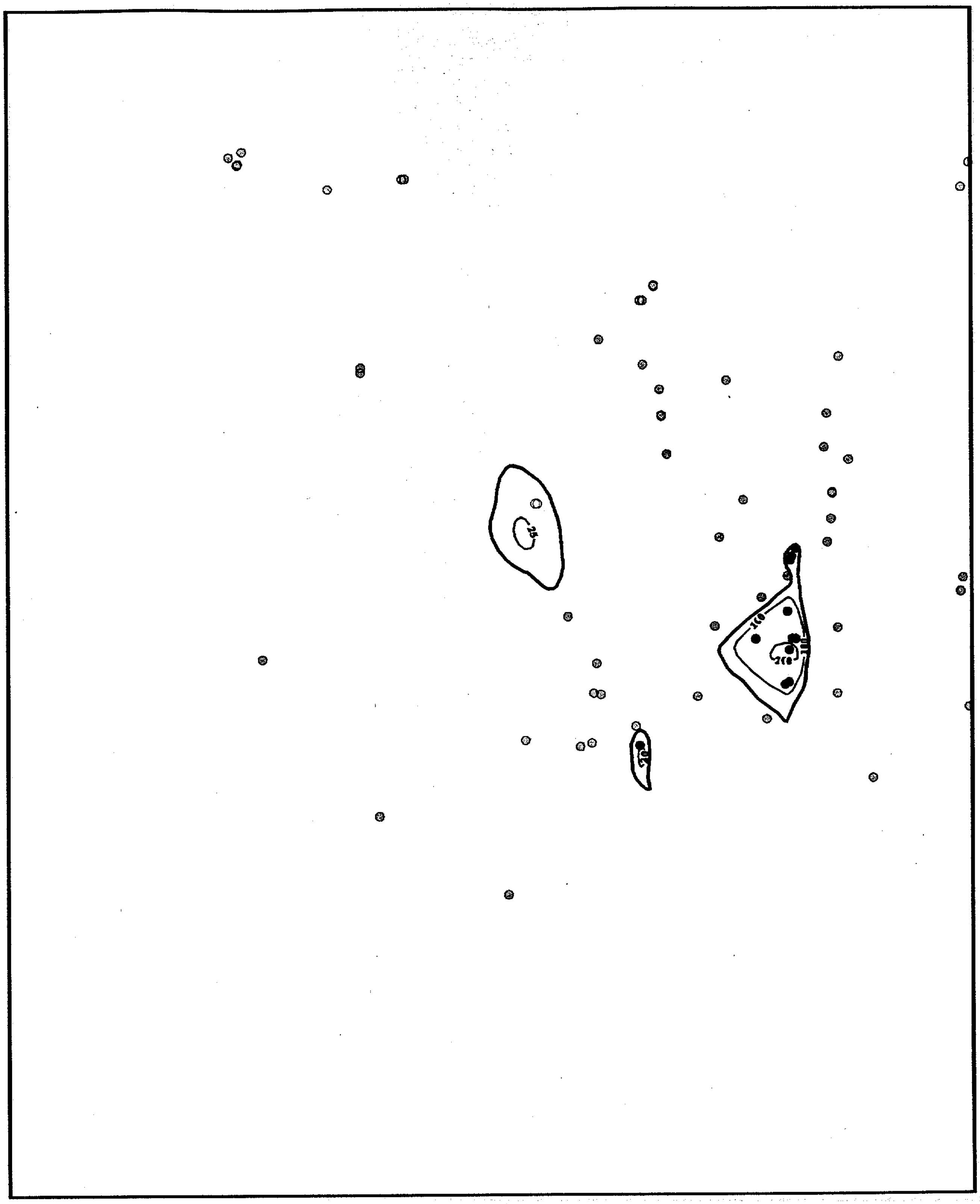

Figure A19. Model isopachs for rhyolite of Windy Wash (Tmw) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Tmw was probably erupted from a single vent in the West Greeley fault, and it thins rapidly away from this vent.

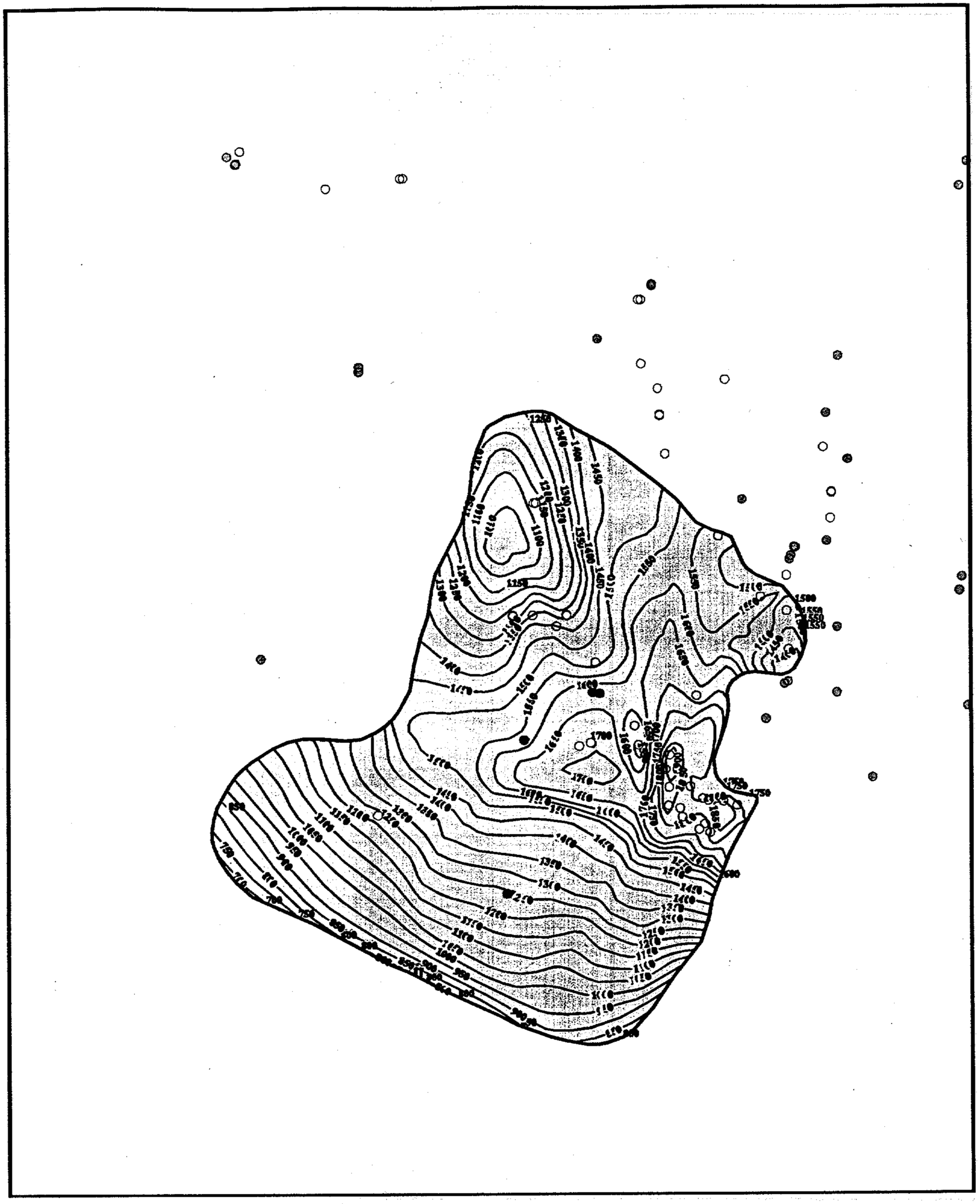

Figure A20. Model elevations for the top of rhyolite of Benham (Tpb) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

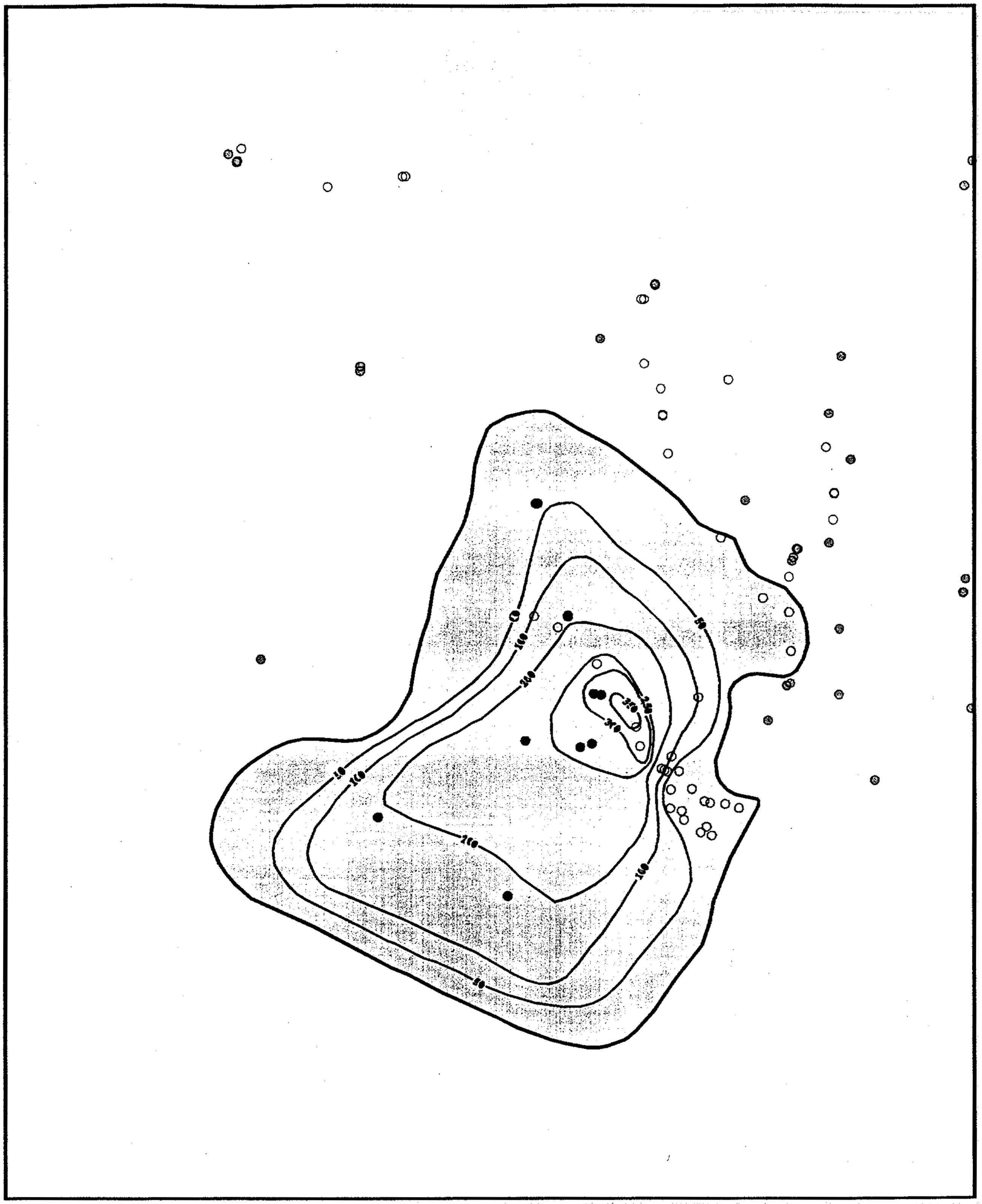

Figure A21. Model isopachs for rhyolite of Benham (Tpb) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Tpb was certainly erupted from the West Boxcar fault, where it is thickest on the downthrown side. Tpb formed a prominent topographic high, resulting in relatively thin deposits for overlying units within the southern part of the Boxcar Trough. Thicknesses of Tpb are similar within the Western Area 20 and Northwestern Timber Mountain Bench structural blocks, indicating that these blocks rotated as a single block prior to eruption of Tpb.

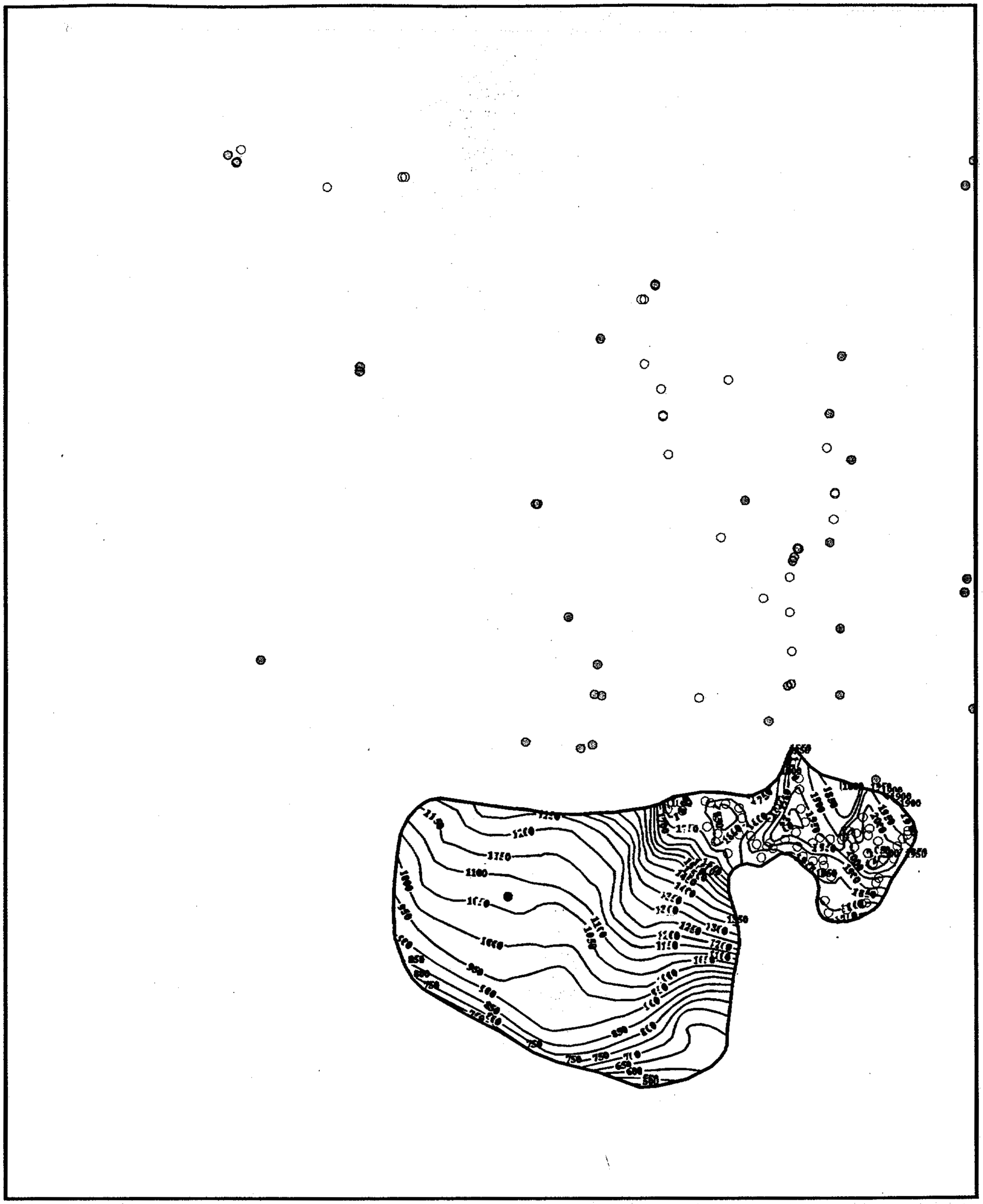

Figure A22. Model elevations for top of rhyolite of Scrugham Peak (Tps) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

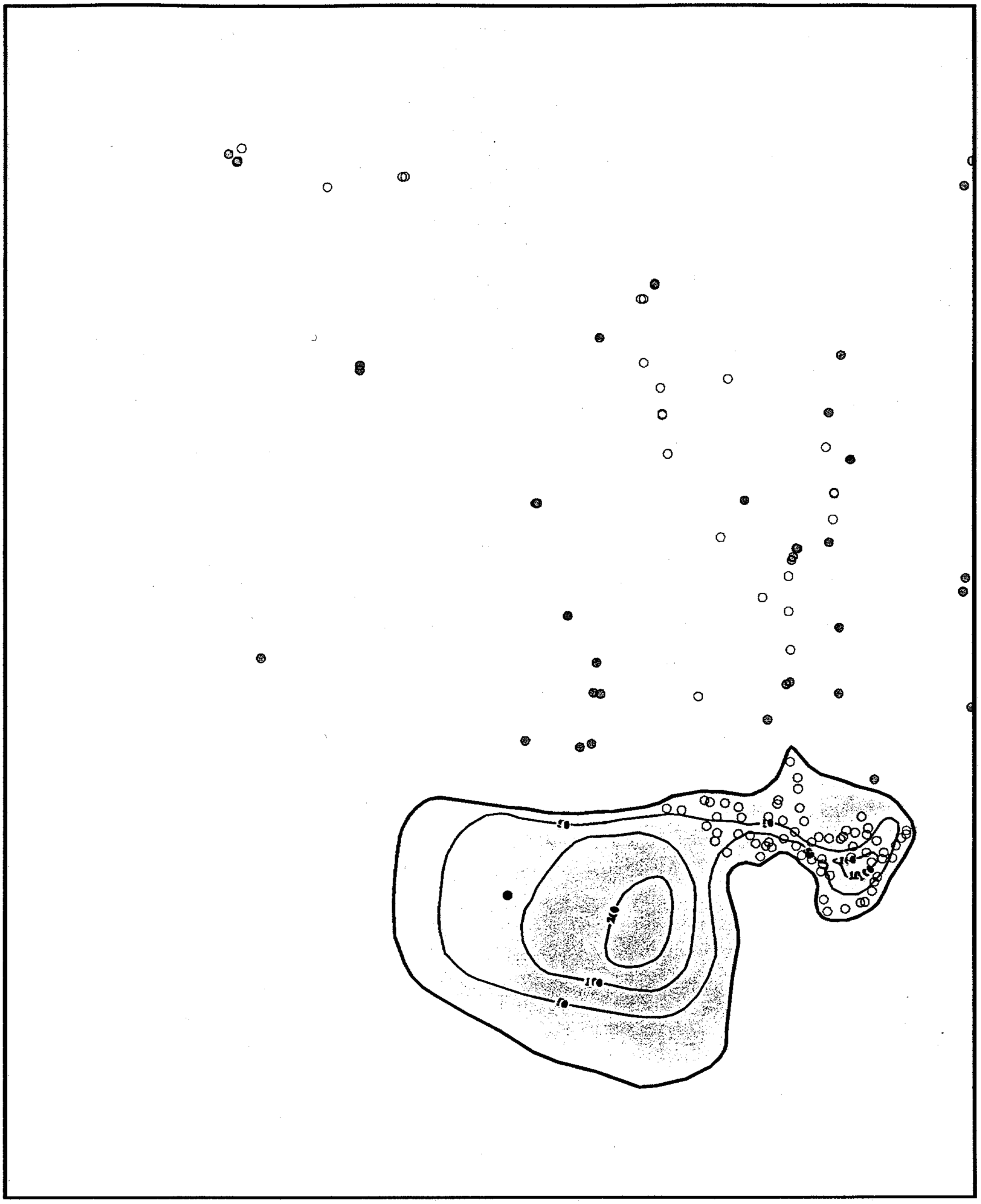

Figure A23. Model isopachs for rhyolite of Scrugham Peak (Tps) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Although Tps is nowhere known to have a thickness >150 m, its widespread extent suggests a source of thick lava within the Northern Timber Mountain Bench structural block.

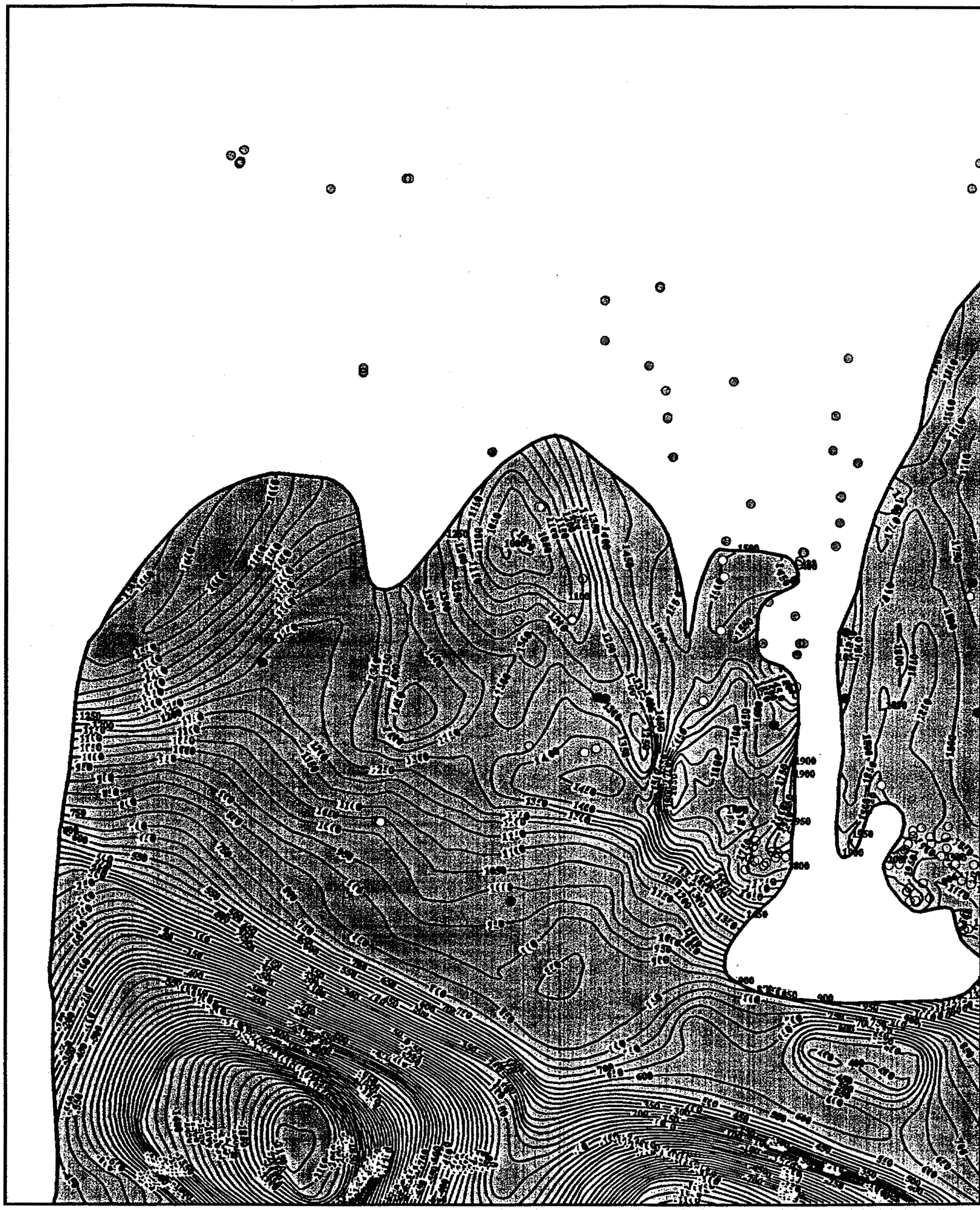

Figure A24. Model elevations for top of Tiva Canyon Tuff (Tpc) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Most of the structural relief within the Western Area 20 structural block can be attributed to northeastward rotation against the West Boxcar fault, which shows 350 m of displacement. A similar rotation within the Eastern Area 20 structural block has resulted in 450 m of displacement across the West Greeley fault. The Northwestern Timber Mountain Bench structural block is 600 m structurally lower than the Western Area 20 block, southward across the structural boundary of the Area 20 caldera. The sense of displacement apparently reverses earlier displacement that forms the southern boundary of the Area 20 caldera, as inferred from elevations of deeper units.

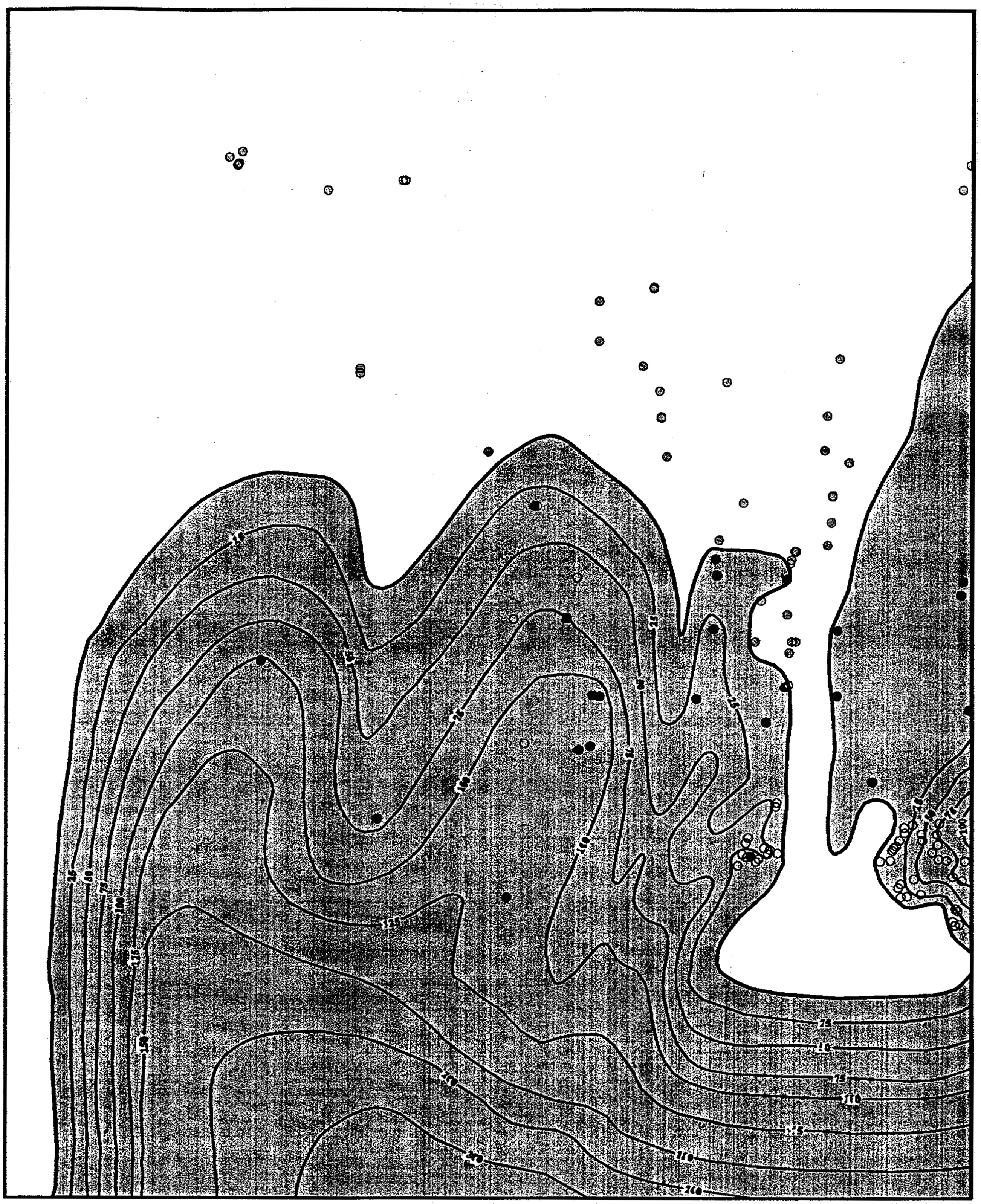

Figure A25. Model isopachs for rhyolite of Tiva Canyon Tuff (Tpc) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Tpc displays two major lobes coincident with the Ribbon Cliff and Boxcar troughs; these lobes certainly reflect the existence of eastward tilted blocks prior to eruption of Tpc.

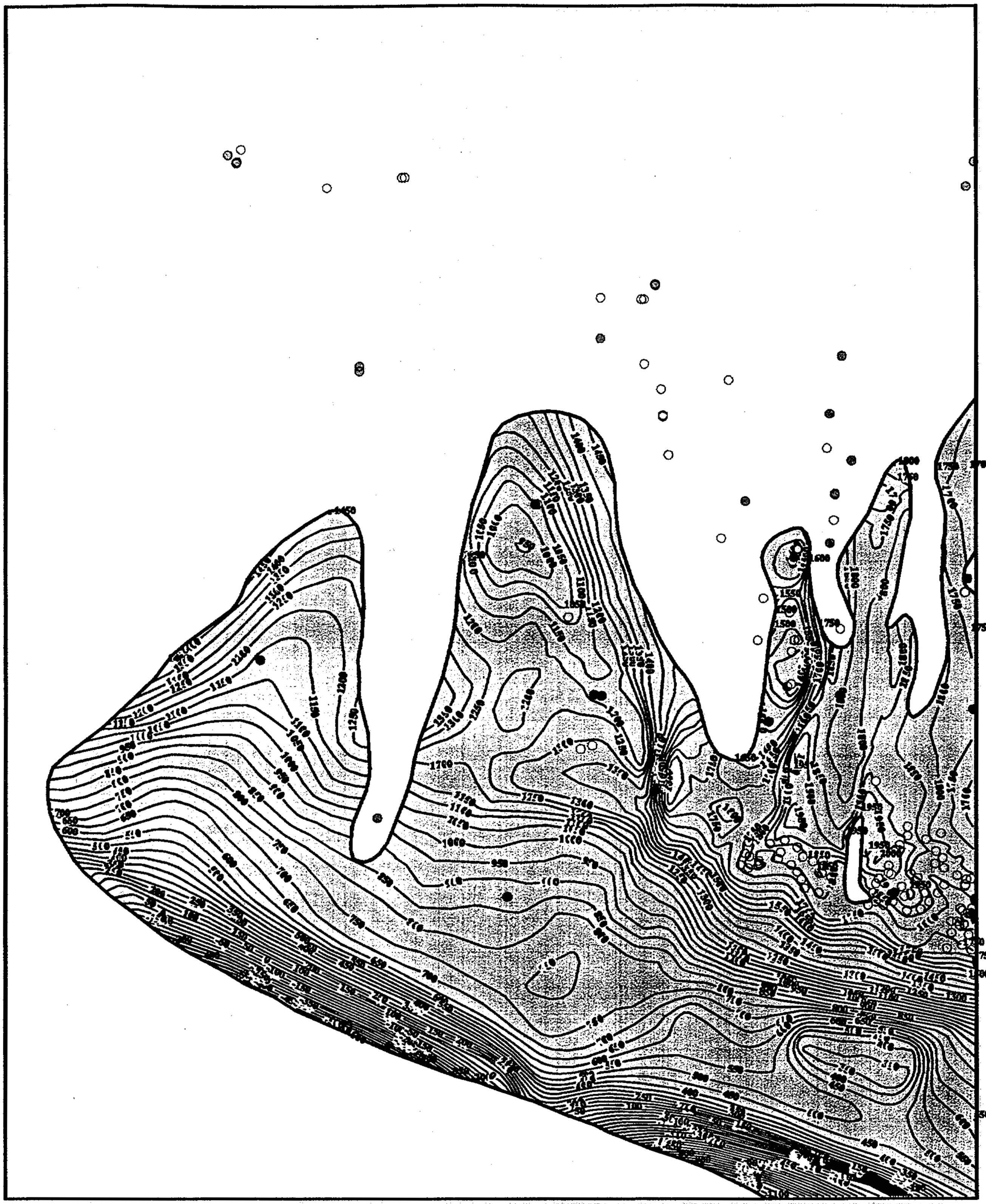

Figure A26. Model elevations for top of rhyolite of Delirium Canyon (Tpd) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

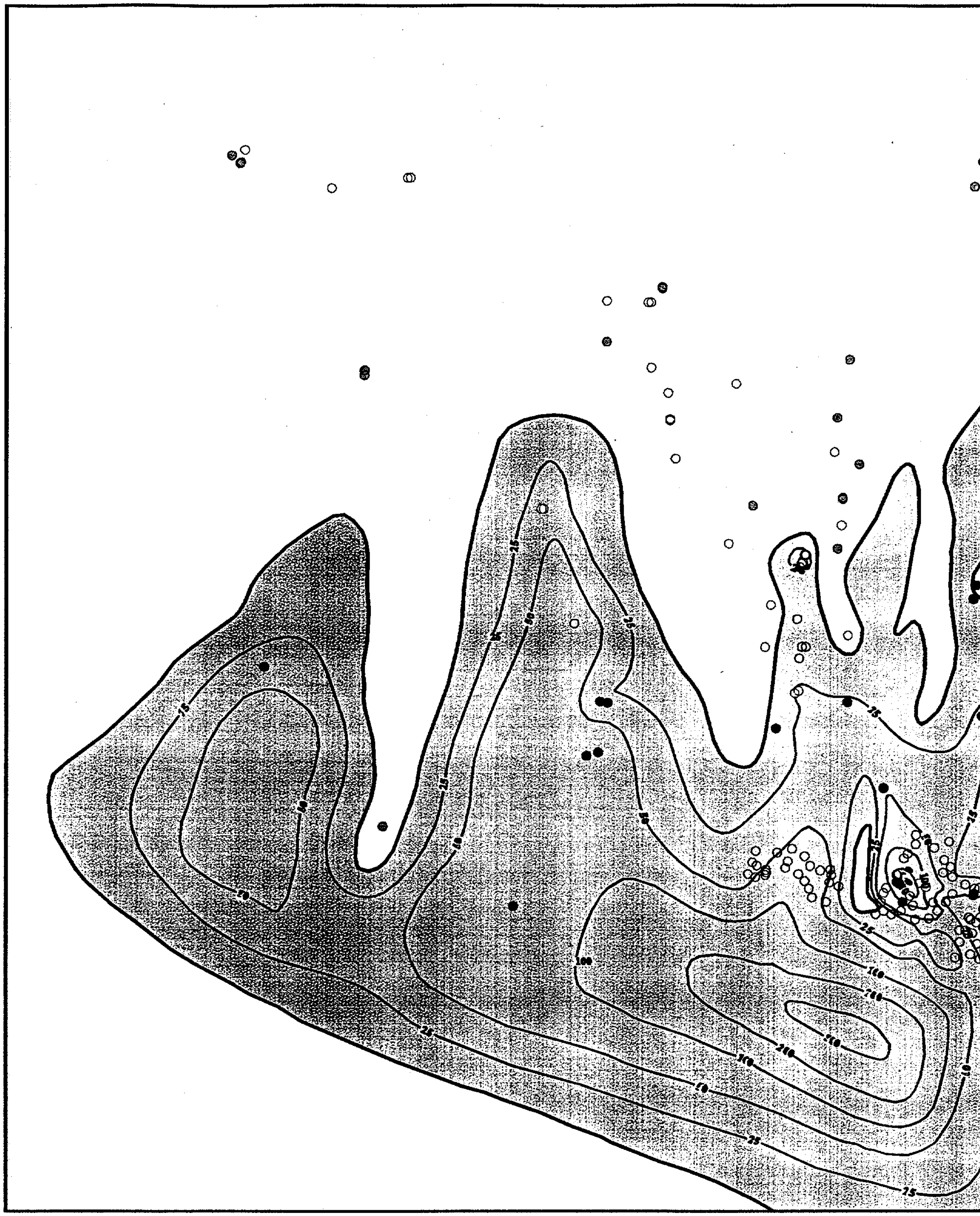

Figure A27. Model isopachs for rhyolite of Delirium Canyon (Tpd) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Although Tpd thins rapidly southward from its greatest known thickness within this region of >200 m, its widespread extent suggests a source of thick lava within the Northern Timber Mountain Bench structural block.

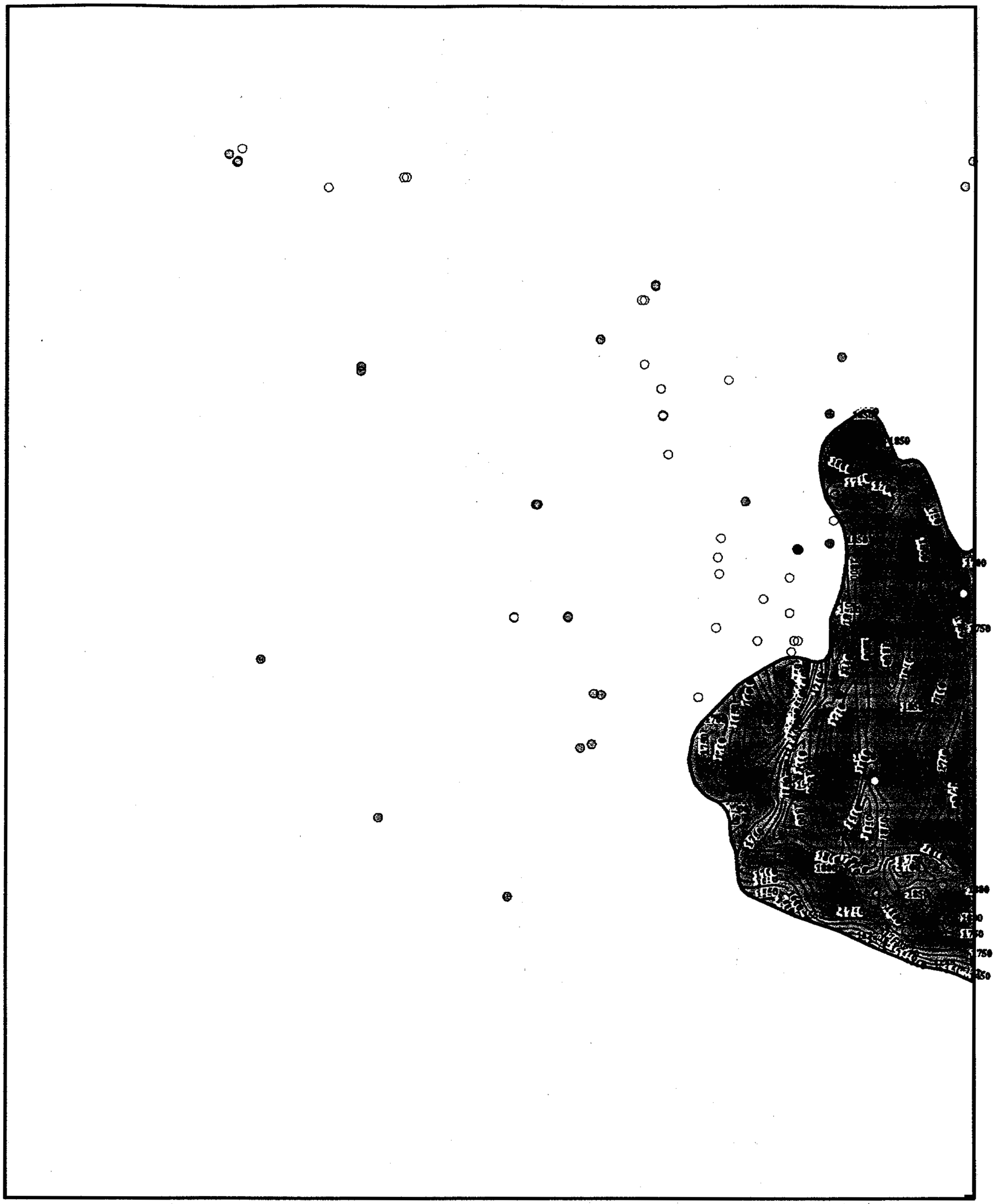

Figure A28. Model elevations for top of rhyolite of Echo Peak (Tpe) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

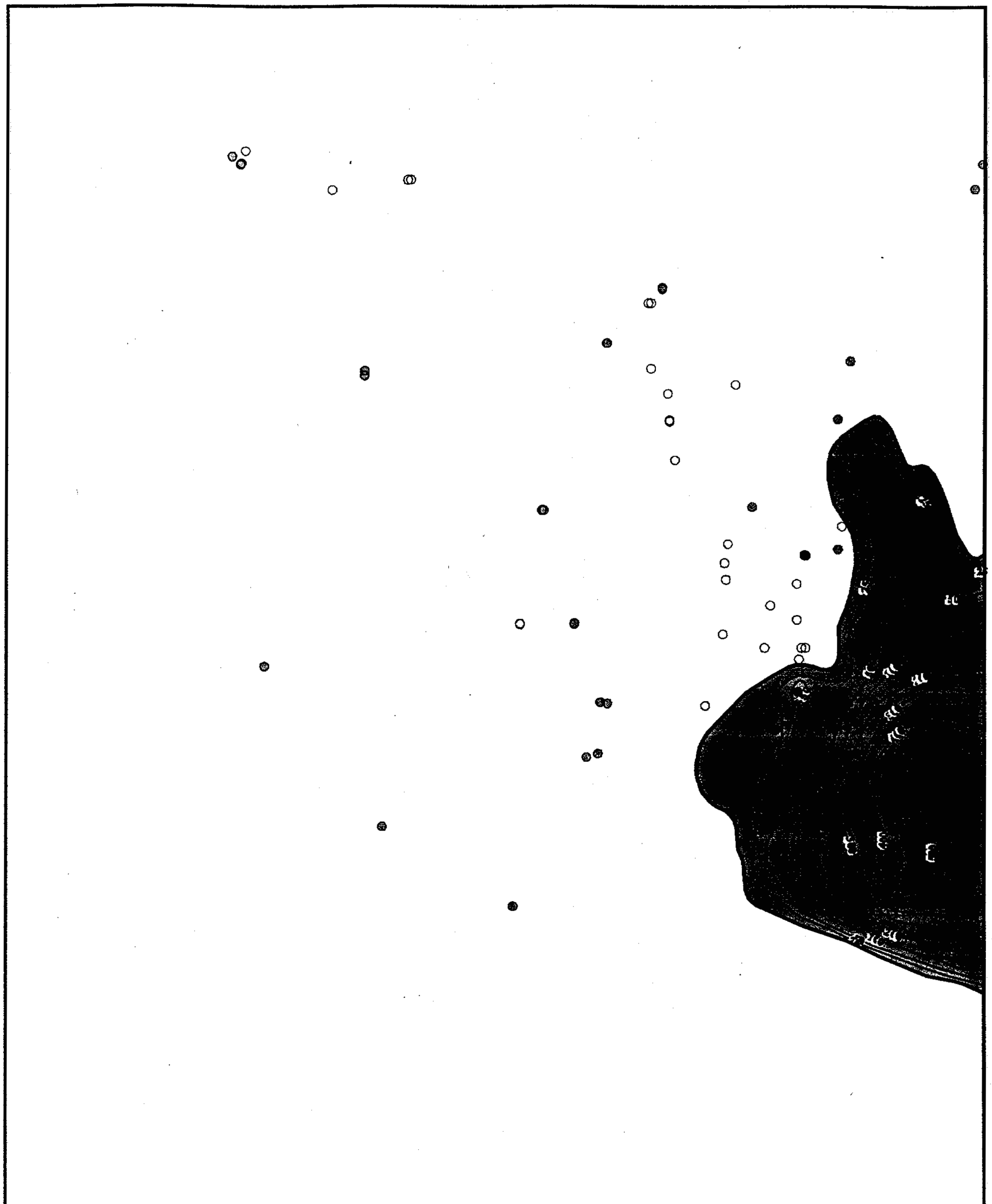

Figure A29. Model isopachs for rhyolite of Echo Peak (Tpe) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. A rapid southward thinning suggests that the topographic wall of Rainier Mesa caldera coincides with a structure that formed a barrier to the southward spread of Tpe.

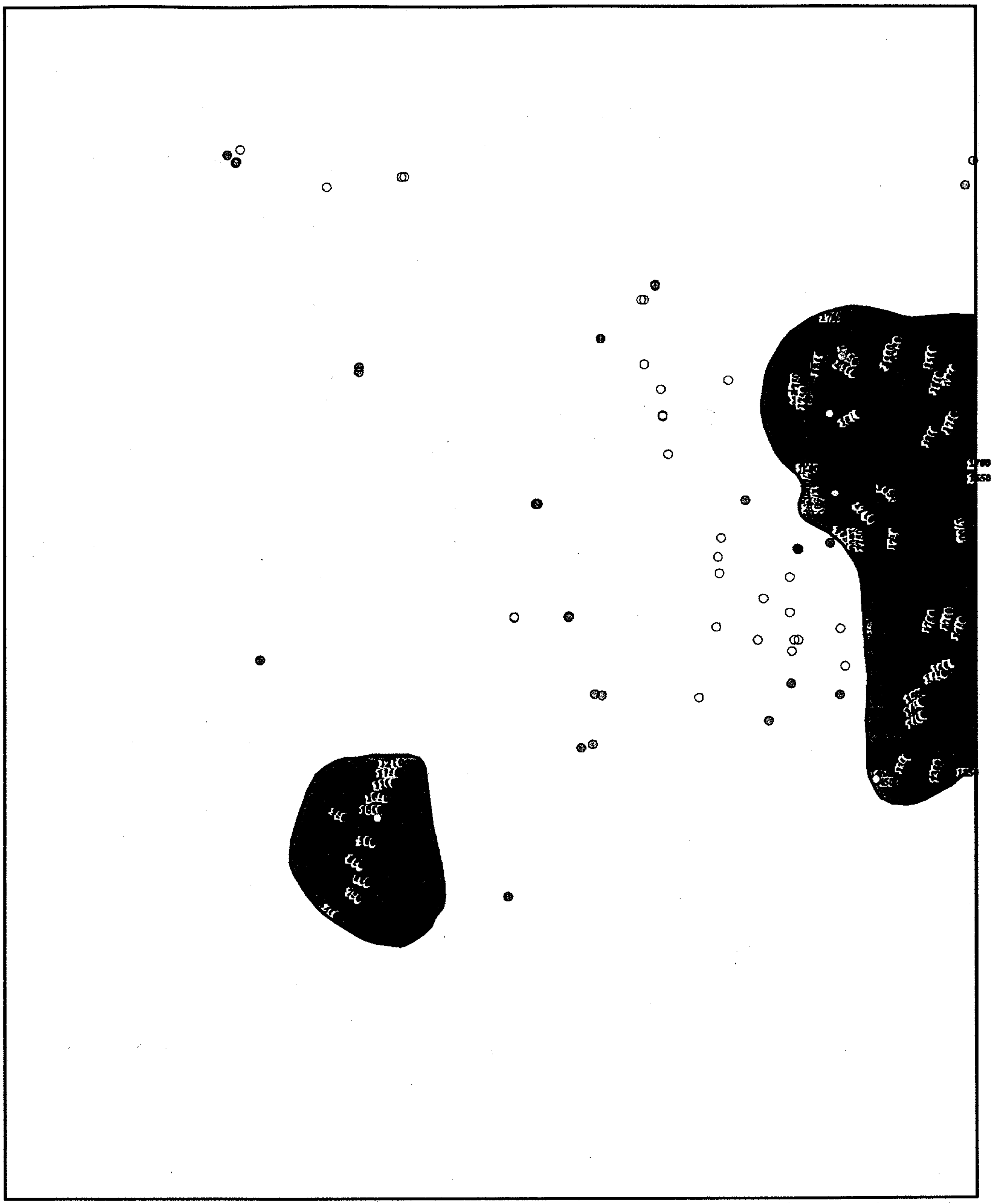

Figure A30. Model elevations for top of rhyolite of Silent Canyon (Tpr) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Note that the southwestern area instead represents landslide breccia of Topopah Spring Tuff (Tptx) in drill hole ER/EC1. This landslide, primarily mafic-rich Calico Hills Formation, originated from a topographically high ridge of that unit north from ER/EC1.

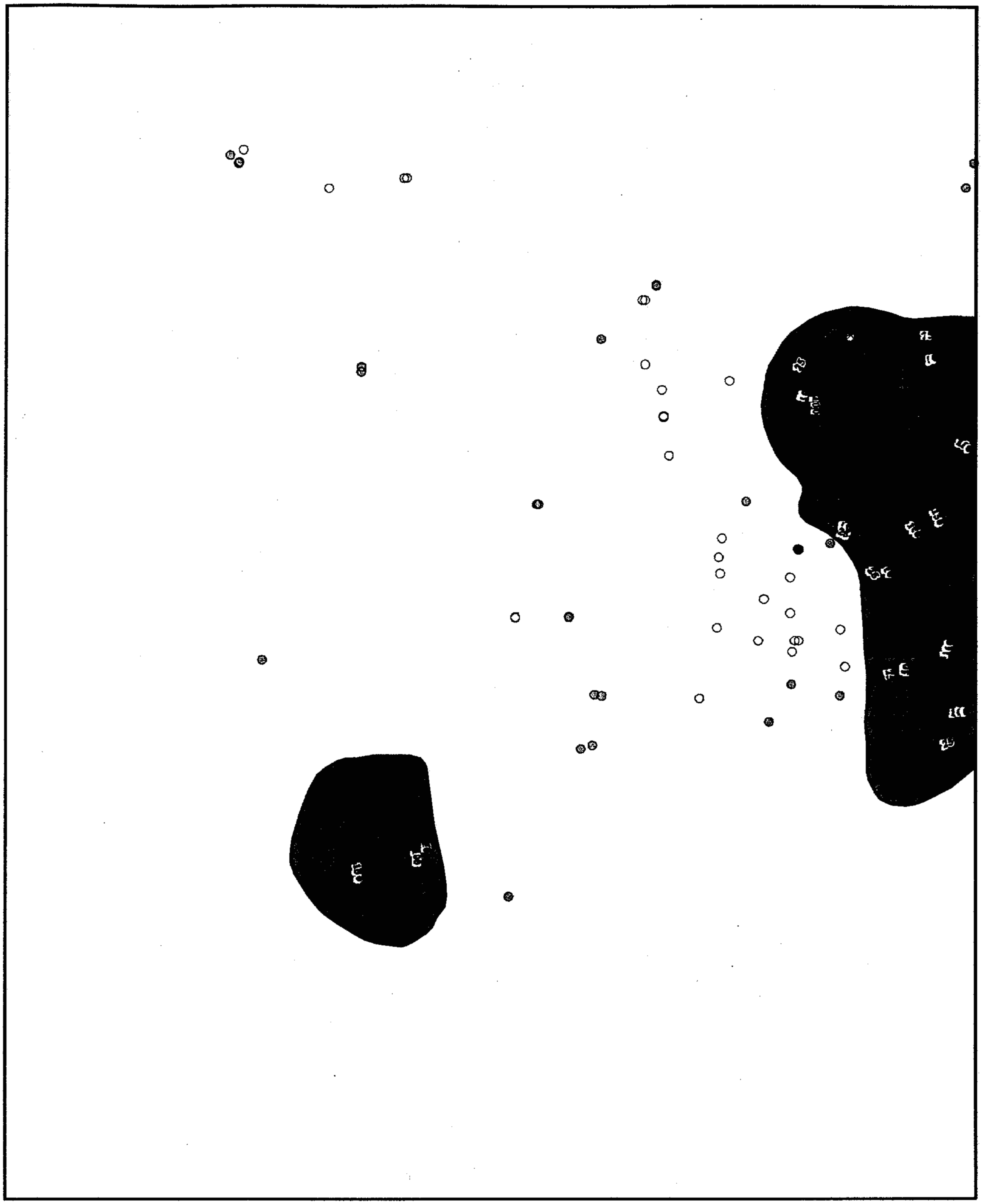

Figure A31. Model isopachs for rhyolite of Silent Canyon (Tpr) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Tpr is wholly confined to the Central Area 19 structural block, suggesting that structural boundaries of this block were active just prior to eruption of Tpr.

Figure A32. Model elevations for top of Topopah Spring Tuff (Tpt) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Model elevations are identical in form to those of Tpc, which should be expected from their ages, which are identical within the narrow time resolution of 40Ar/39Ar dating methods (Table 2).

Figure A33. Model isopachs for Topopah Spring Tuff (Tpt) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Like Tpc, Tpt displays two major lobes coincident with the Ribbon Cliff and Boxcar troughs; these lobes certainly reflect the existence of eastward tilted blocks prior to eruption of Tpt.

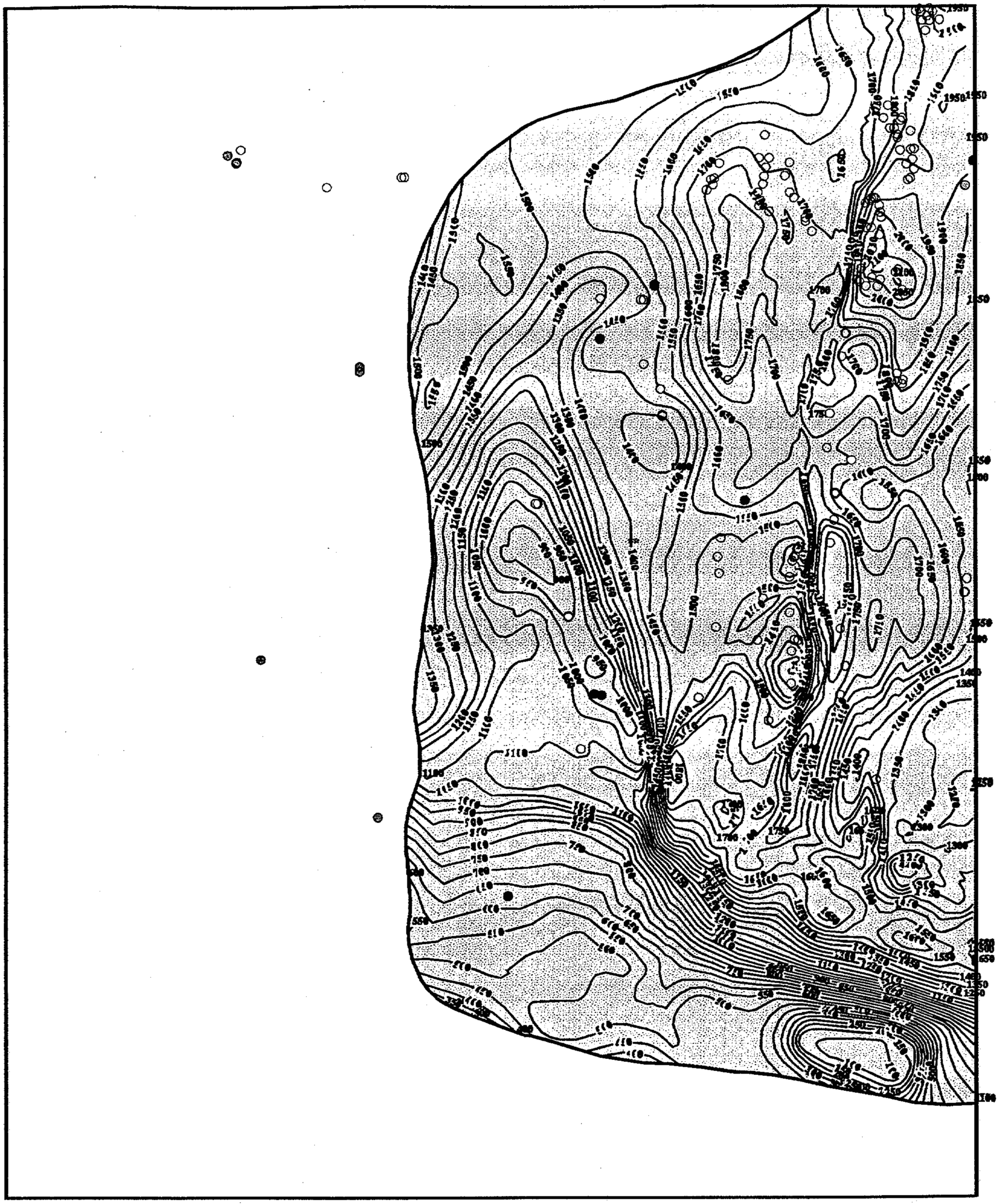

Figure A34. Model elevations for top of mafic-poor Calico Hills Formation (Thp) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Displacement of Thp is 650 m across the West Greeley fault, and 750 m across the West Boxcar fault. The large differences between these displacements and those for Tpt (identical to displacements for Tpc) despite an age difference of only 0.1 Ma between Thp and Tpt (Sawyer et al., 1994) indicates that both faults probably provided conduits for eruption of Thp.

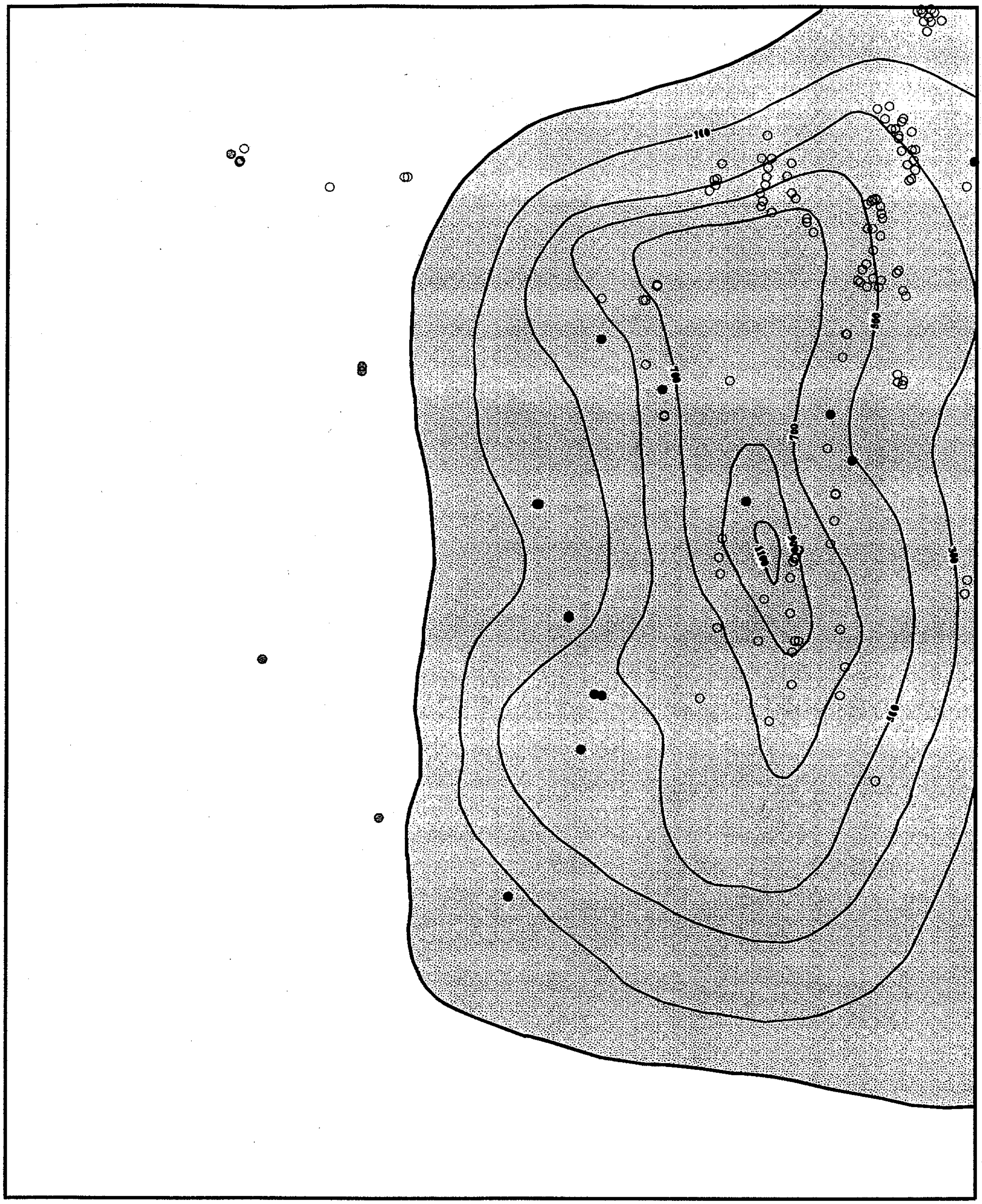

Figure A35. Model isopachs for mafic-poor Calico Hills Formation (Thp) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Thp appears to represent the final episode of magmatic activity within the Area 20 caldera (Ferguson et al., 1994), and thus displays thicknesses that far exceed those of any younger unit. Structural data from ER/EC6 suggest a southward disappearance of Thp, but instead could reflect a southward constriction of the unit.

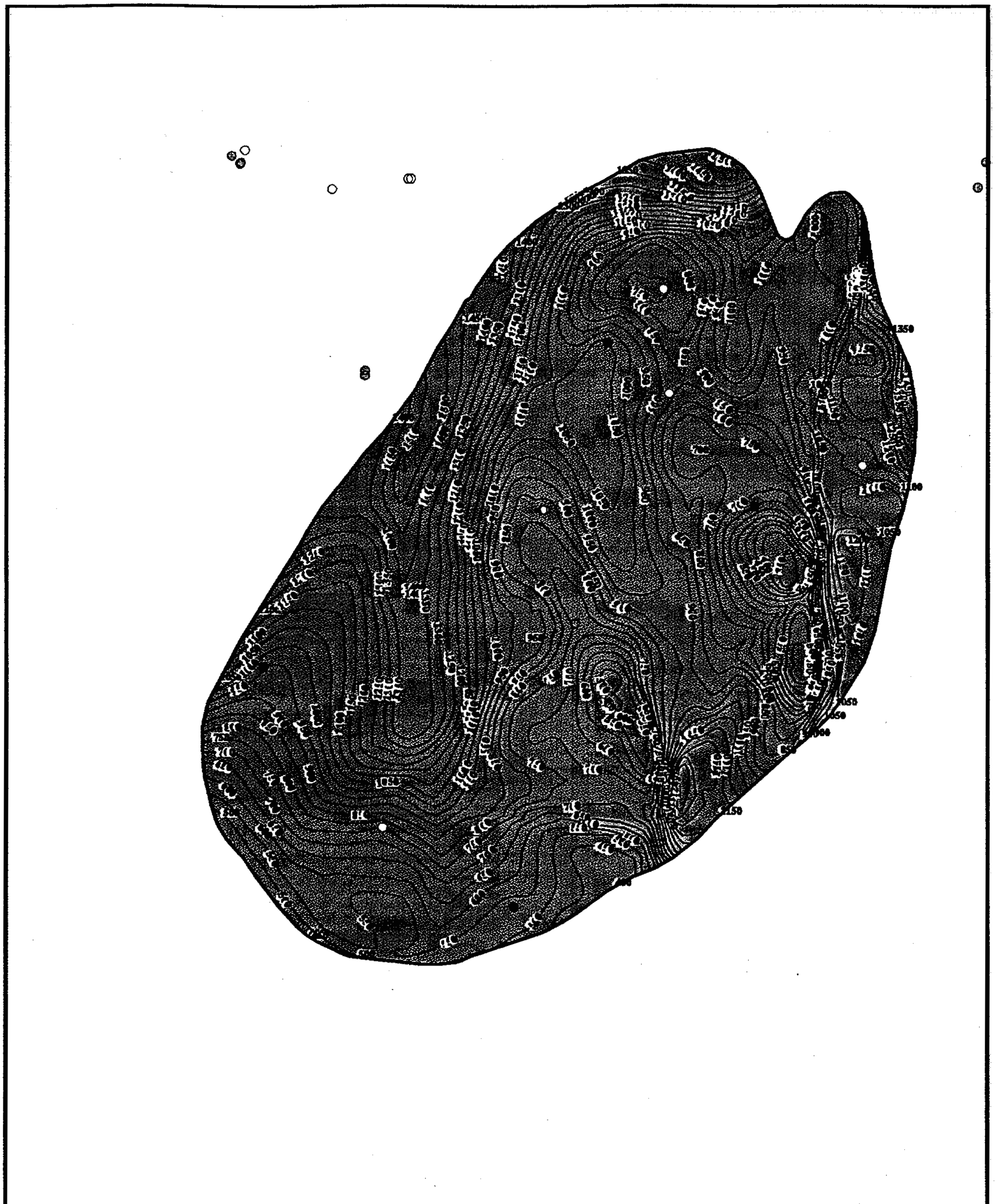

Figure A36. Model elevations for top of mafic-rich Calico Hills Formation (Thr) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

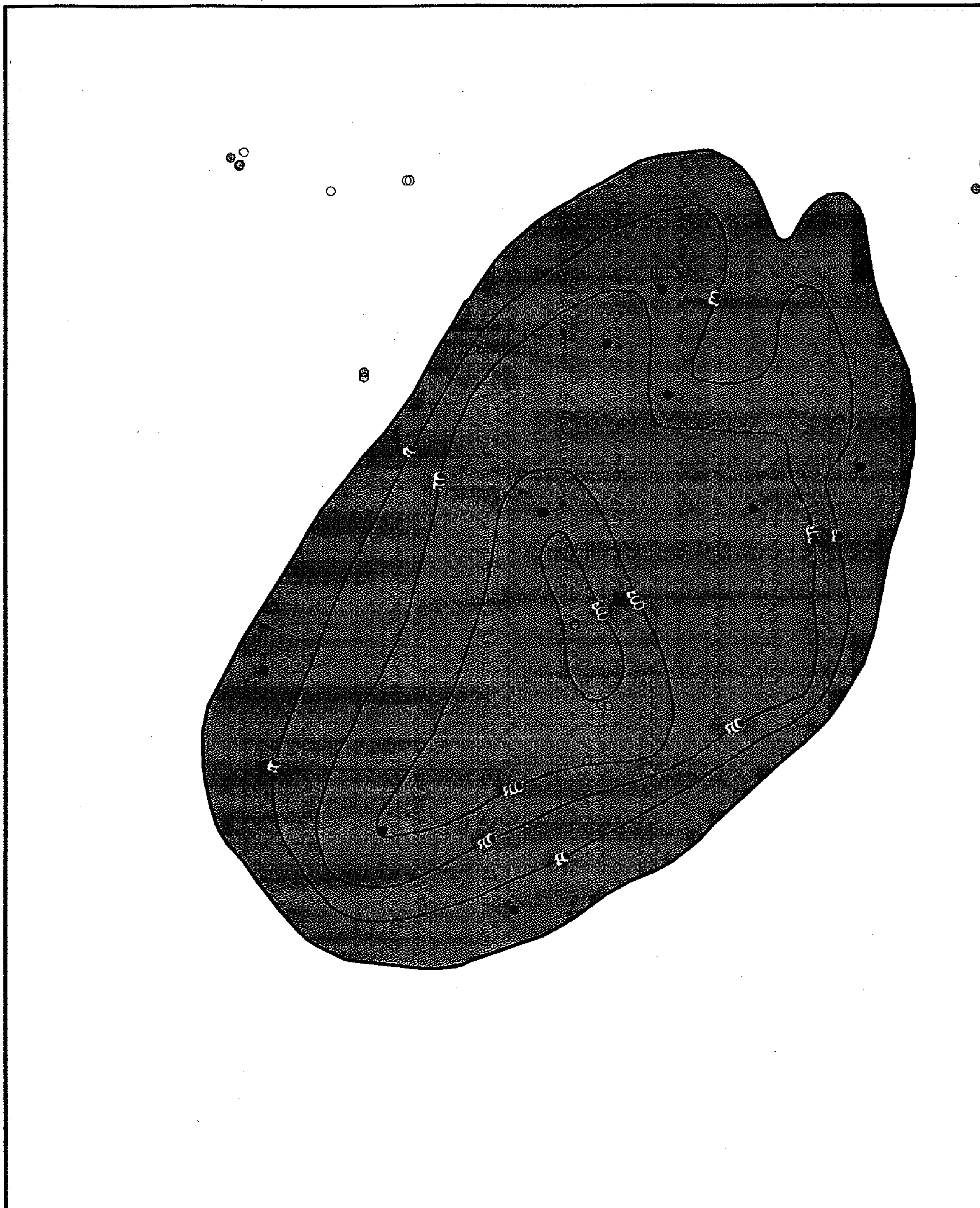

Figure A37. Model isopachs for mafic-rich Calico Hills Formation (Thr) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

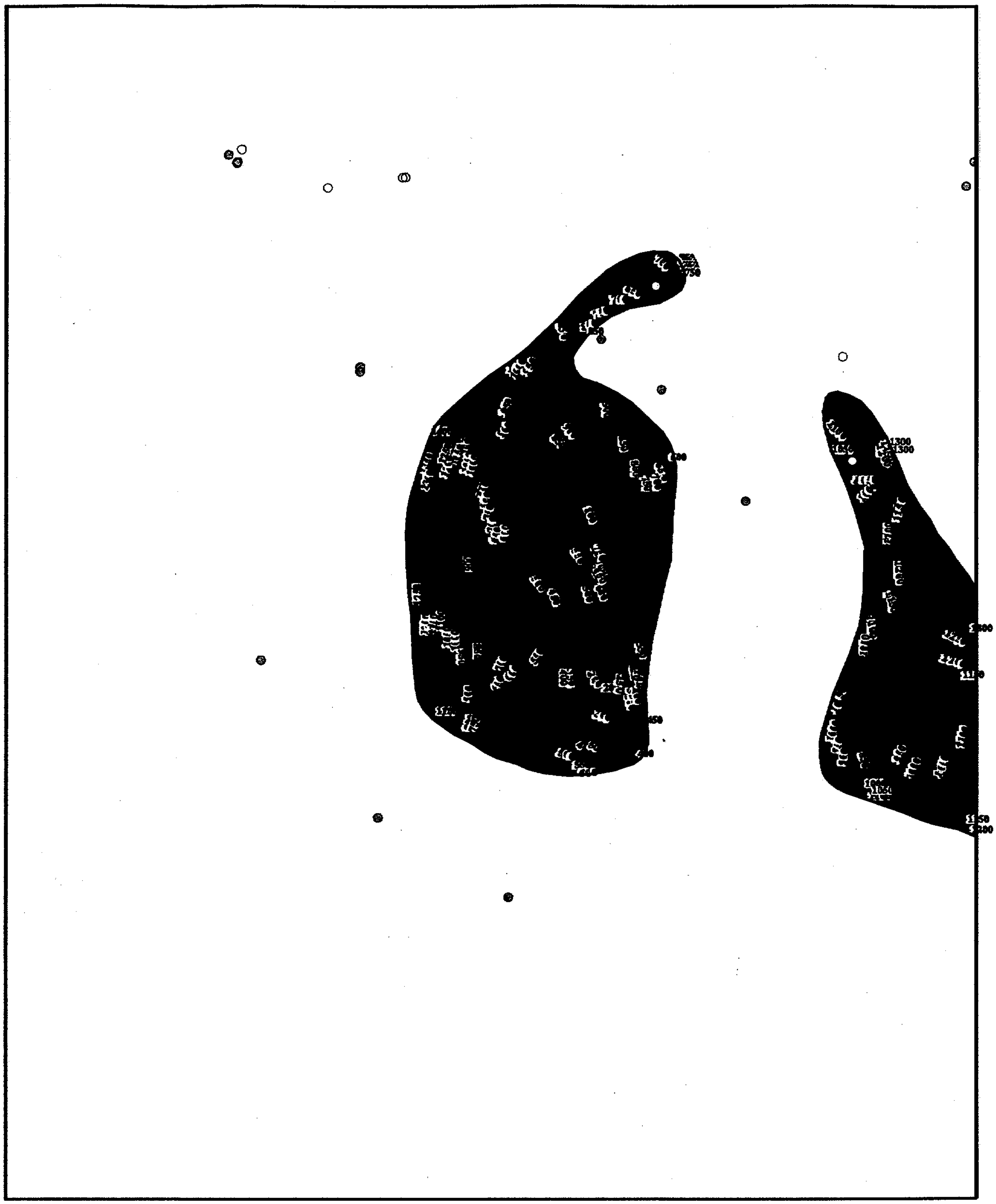

Figure A38. Model elevations for top of rhyolite of Inlet (Tci) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

Figure A39. Model isopachs for rhyolite of Inlet (Tci) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Tci is very thick in UE20F and in UE19F\S, but thin or absent at all other subsurface locations where the datum is penetrated. The unit evidently fills the Area 20 caldera west of the Boxcar fault, and a region southeast of this caldera that collapsed to enlarge the caldera during or prior to eruption of Tci (Ferguson et al., 1994). Note that overlying tuff of Pool (Tcu) and underlying basalt of Fontina (Tcf) are included with Tci. Within this region Tcu has a maximum thickness of 21 m, and Tcf occurs only in UE20F, where it is 5 m thick.

Figure A40. Model elevations for top of rhyolite of Jorum (Tcj) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

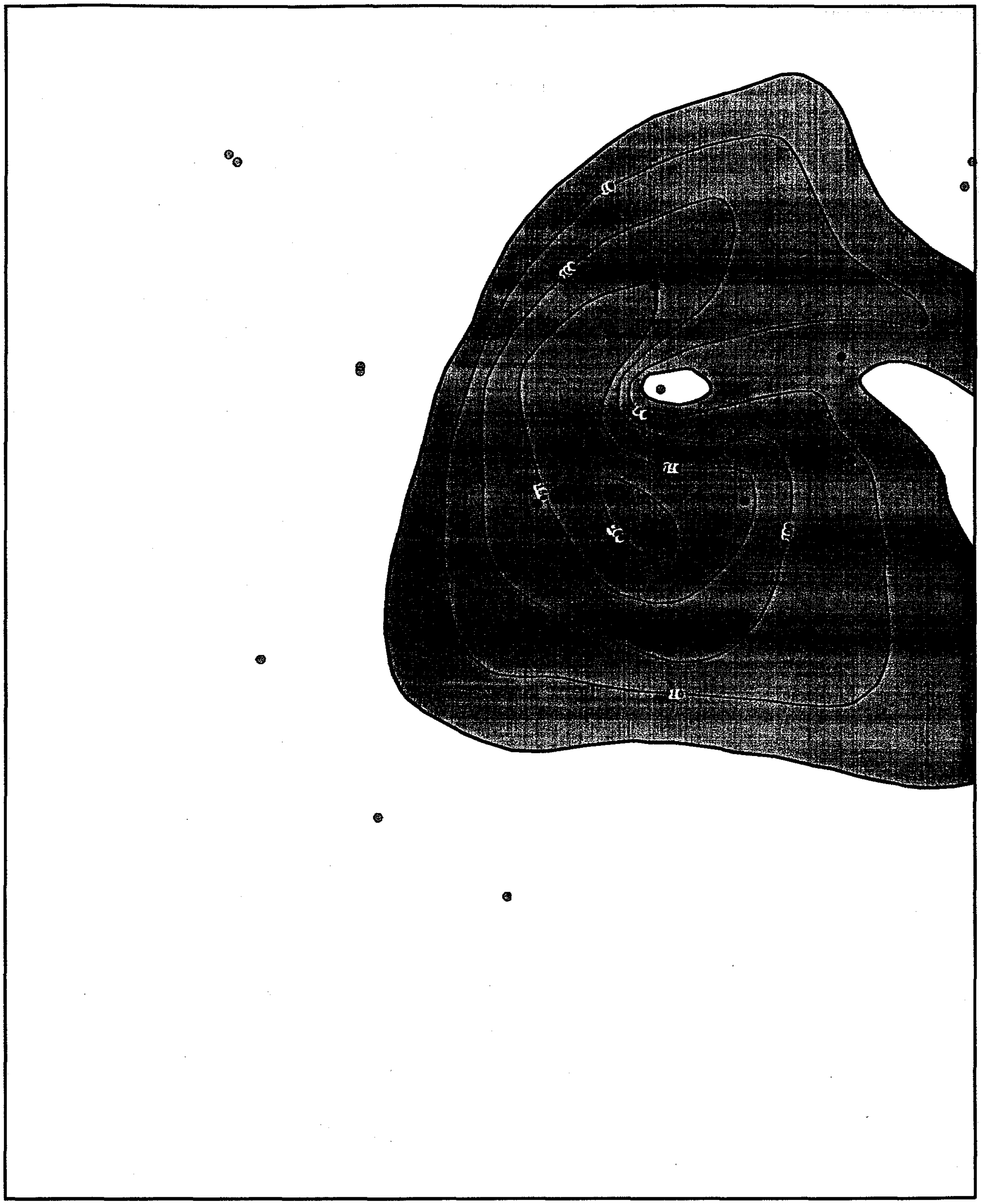

Figure A41. Model isopachs for rhyolite of Jorum (Tcj) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Tcj appears to fill and overflow the Area 20 caldera west of the Boxcar or West Greeley fault.

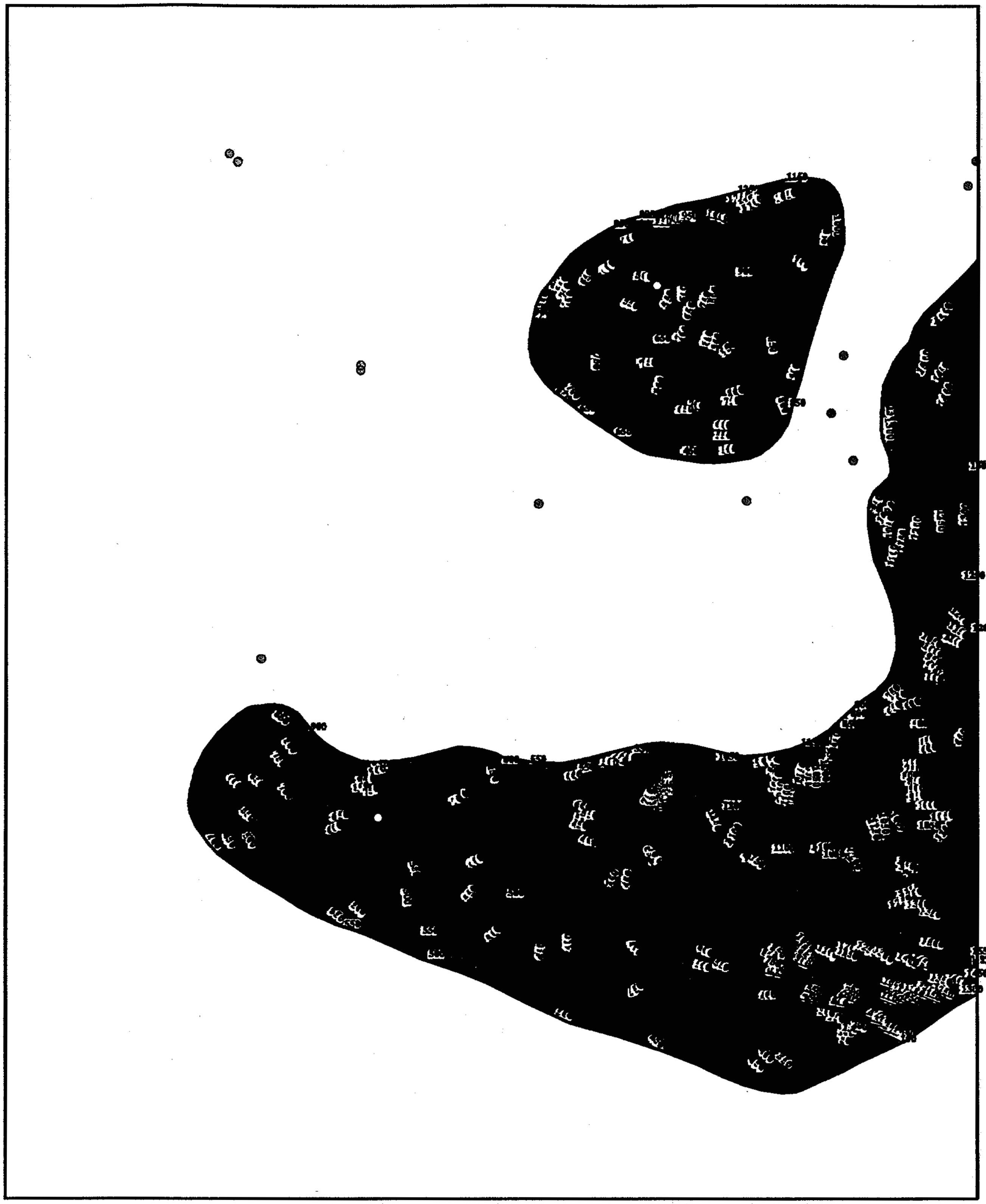

Figure A42. Model elevations for top of rhyolite of Sled (Tcps) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Southern arm of unit represents rhyolite of ER/EC1 (Tcpe), a very closely related unit that appears to have been deposited outside the southwestern boundary of the Area 20 caldera. Tcps appears to have been deposited outside the northwestern boundary of the Area 20 caldera.

Figure A43. Model isopachs for rhyolite of Sled (Tcps) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

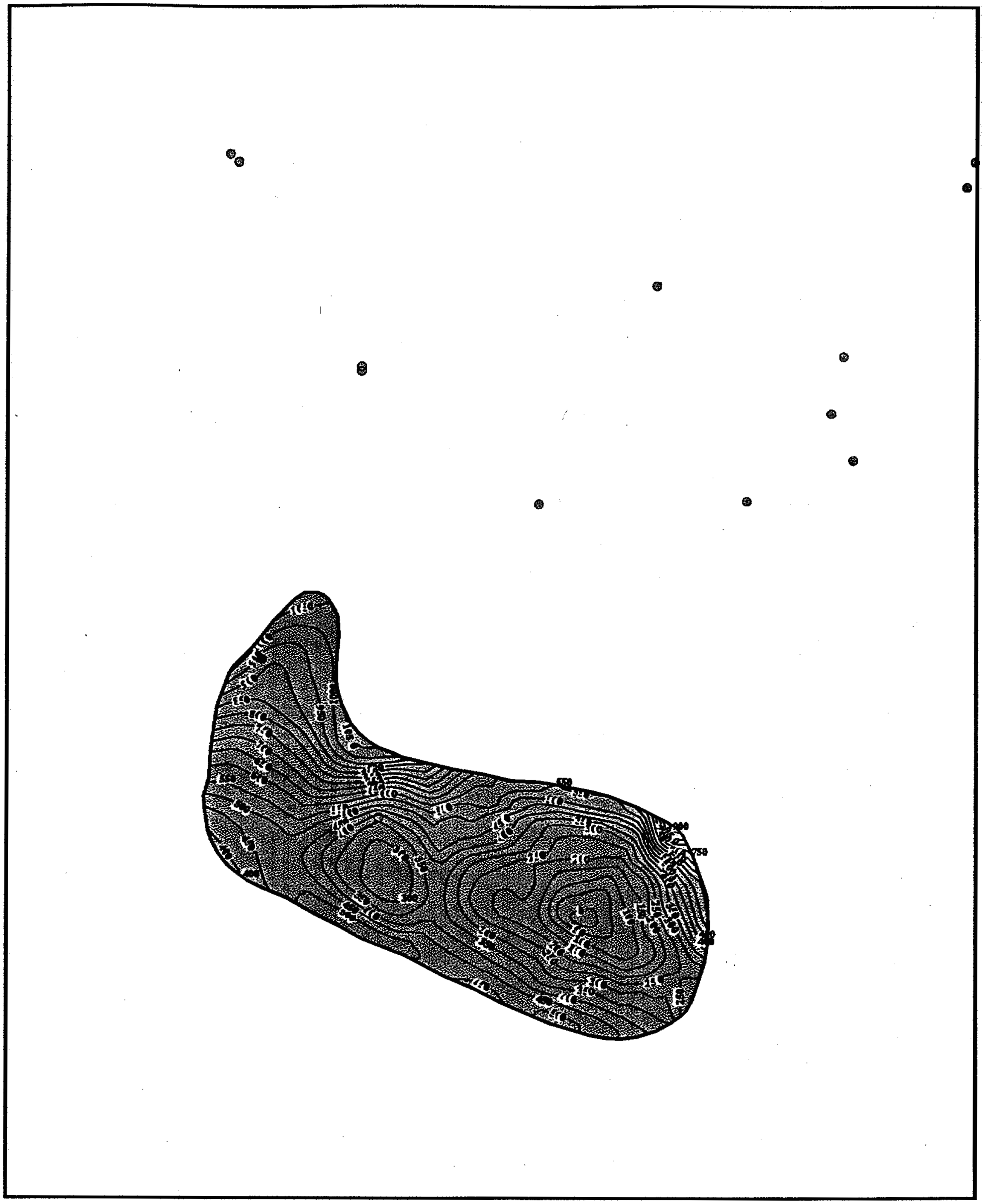

Figure A44. Model elevations for top of rhyolite of Kearsarge (Tcpk) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. West of West Greeley fault, Tcpk was penetrated only in ER/EC1, where it apparently was deposited outside the southwestern boundary of the Area 20 caldera. Tcpk was also deposited outside the northeastern boundary of the Area 20 caldera, east of the region shown in this figure. Note that the northwestern arm instead represents andesite of Grimy Gulch (Tcg) in drill hole PM3.

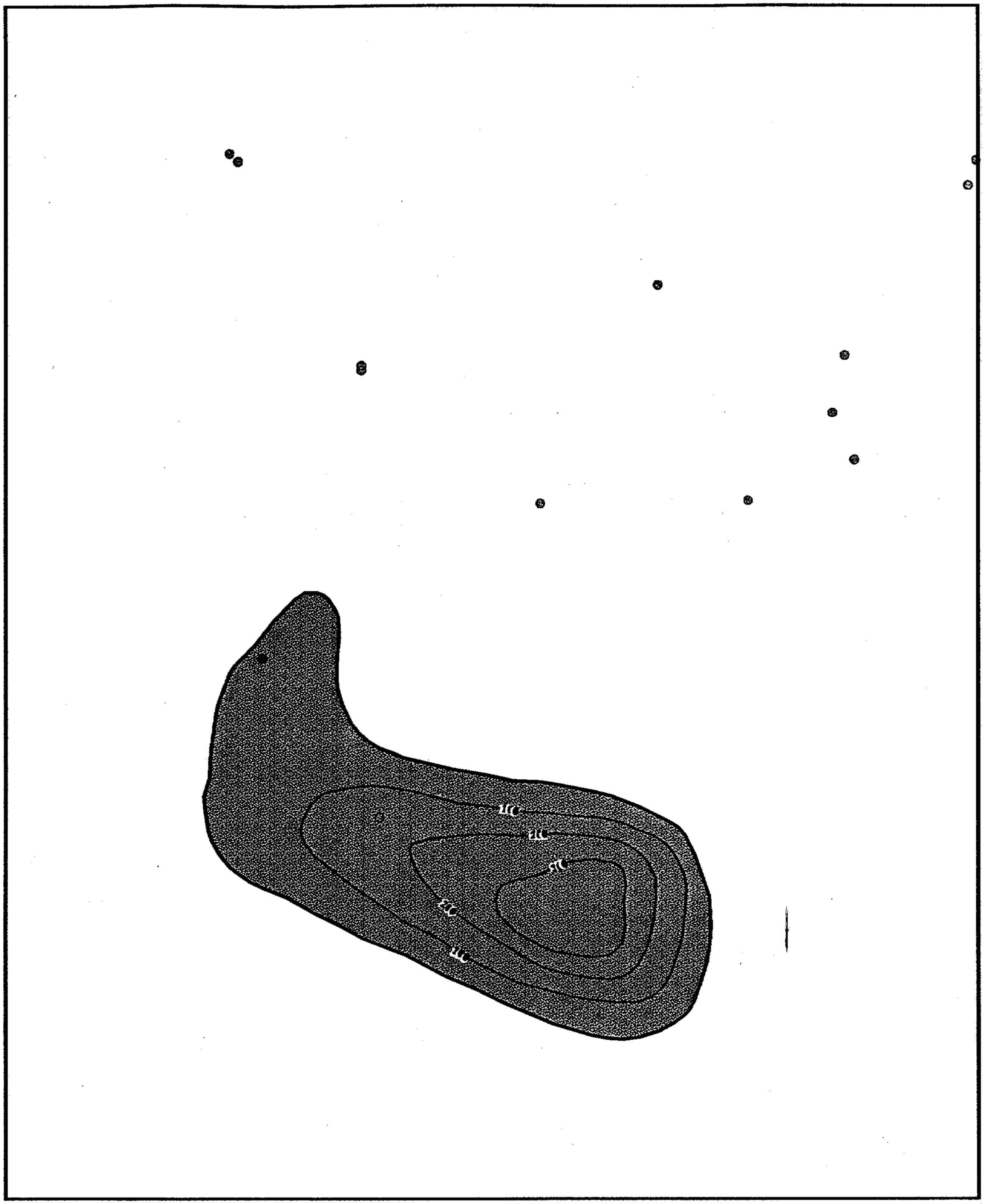

Figure A45. Model isopachs for rhyolite of Kearsarge (Tcpk) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2.

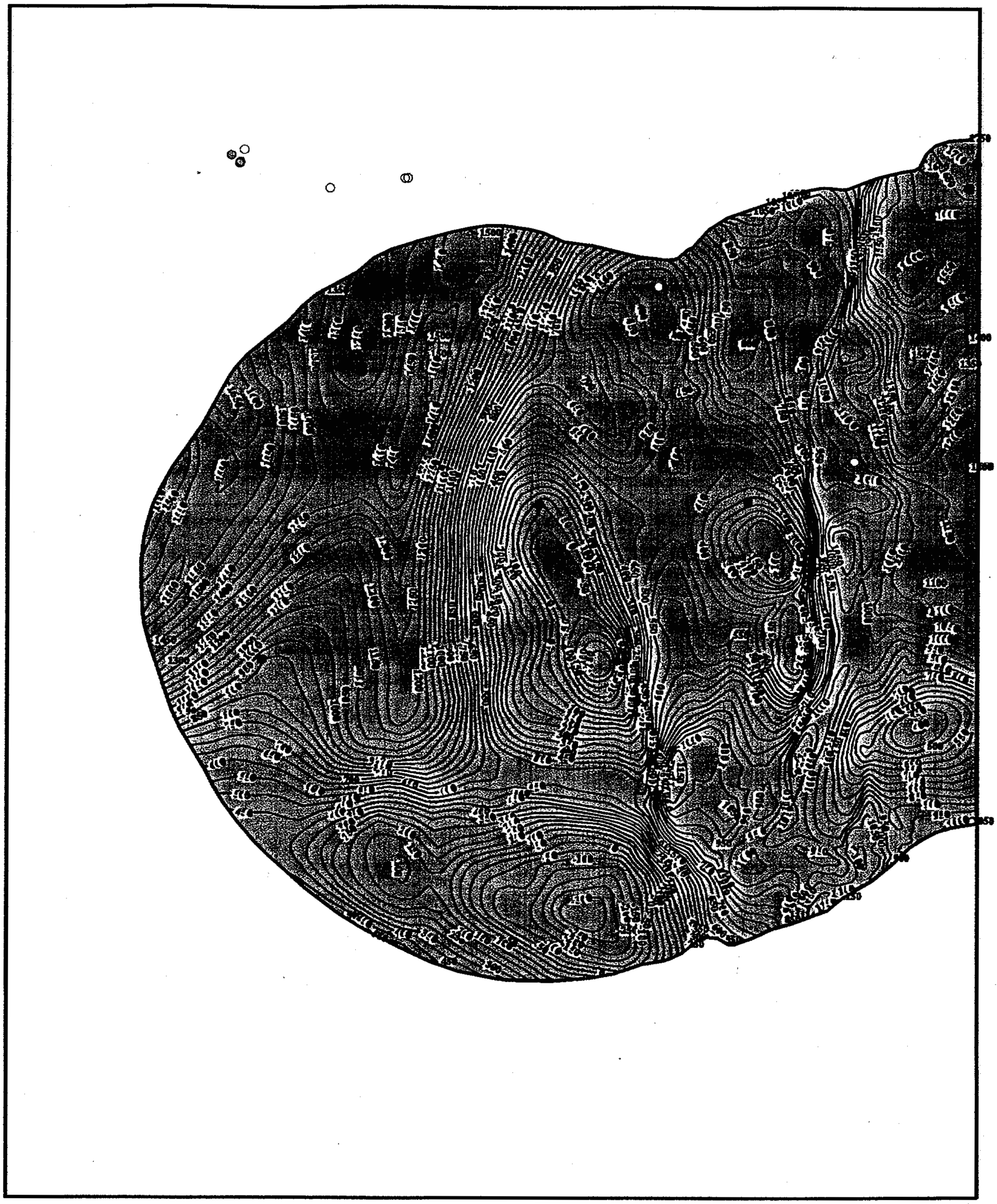

Figure A46. Model elevations for top of Bullfrog Tuff (Tcb) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Displacement of Tcb is 950 m across the West Greeley fault, and 850 m across the West Boxcar fault. Tcb is displaced 1300 m down eastward across the Purse and West Purse faults, a sense opposite to surficial displacement across these faults, defining a graben filled primarily by Thp (Ferguson et al., 1994).

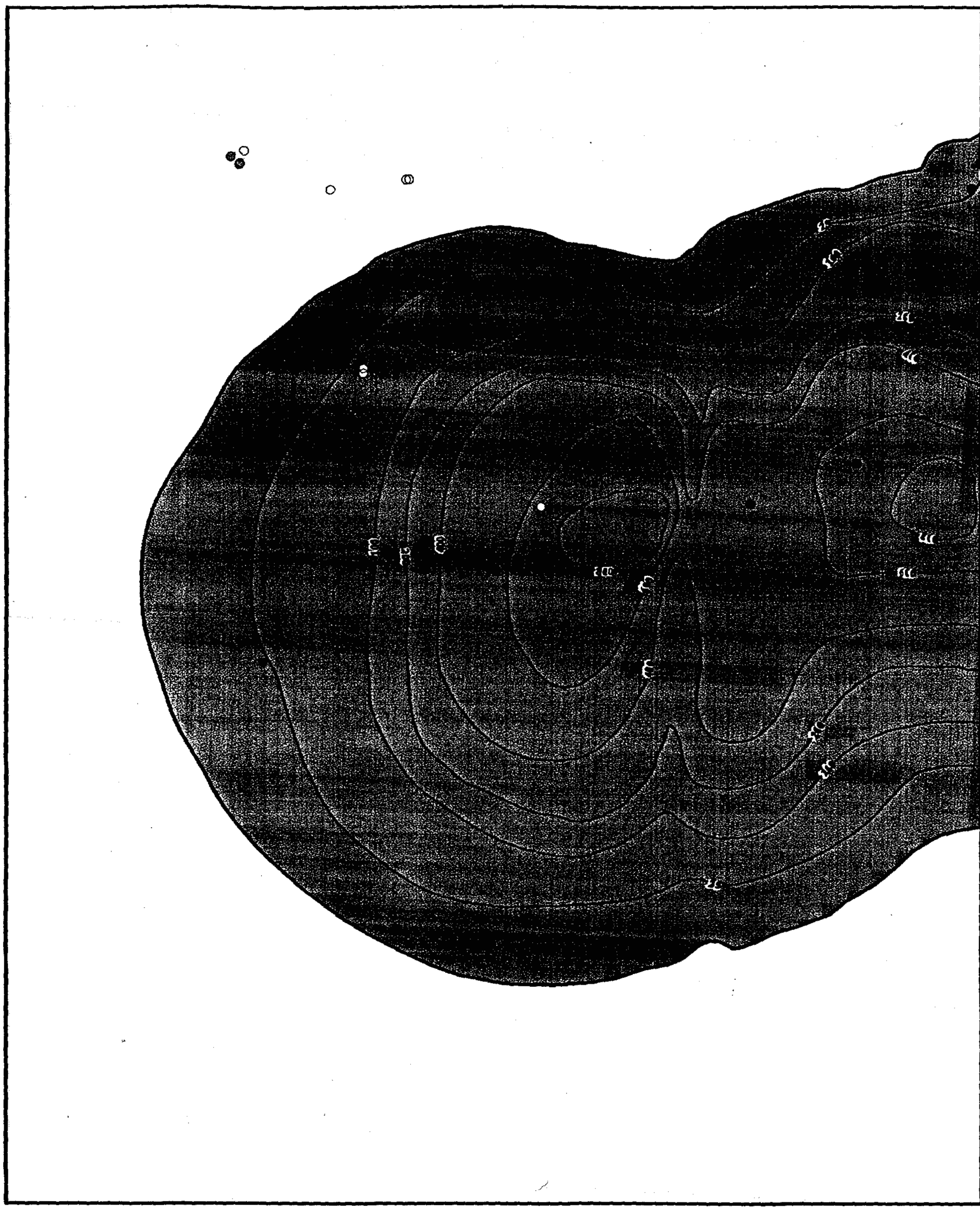

Figure A47. Model isopachs for Bullfrog Tuff (Tcb) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Relatively thin Tcb within Area 20 caldera in UE20H could be attributed to resurgence rather than to pre-existing offset as shown across Boxcar fault.

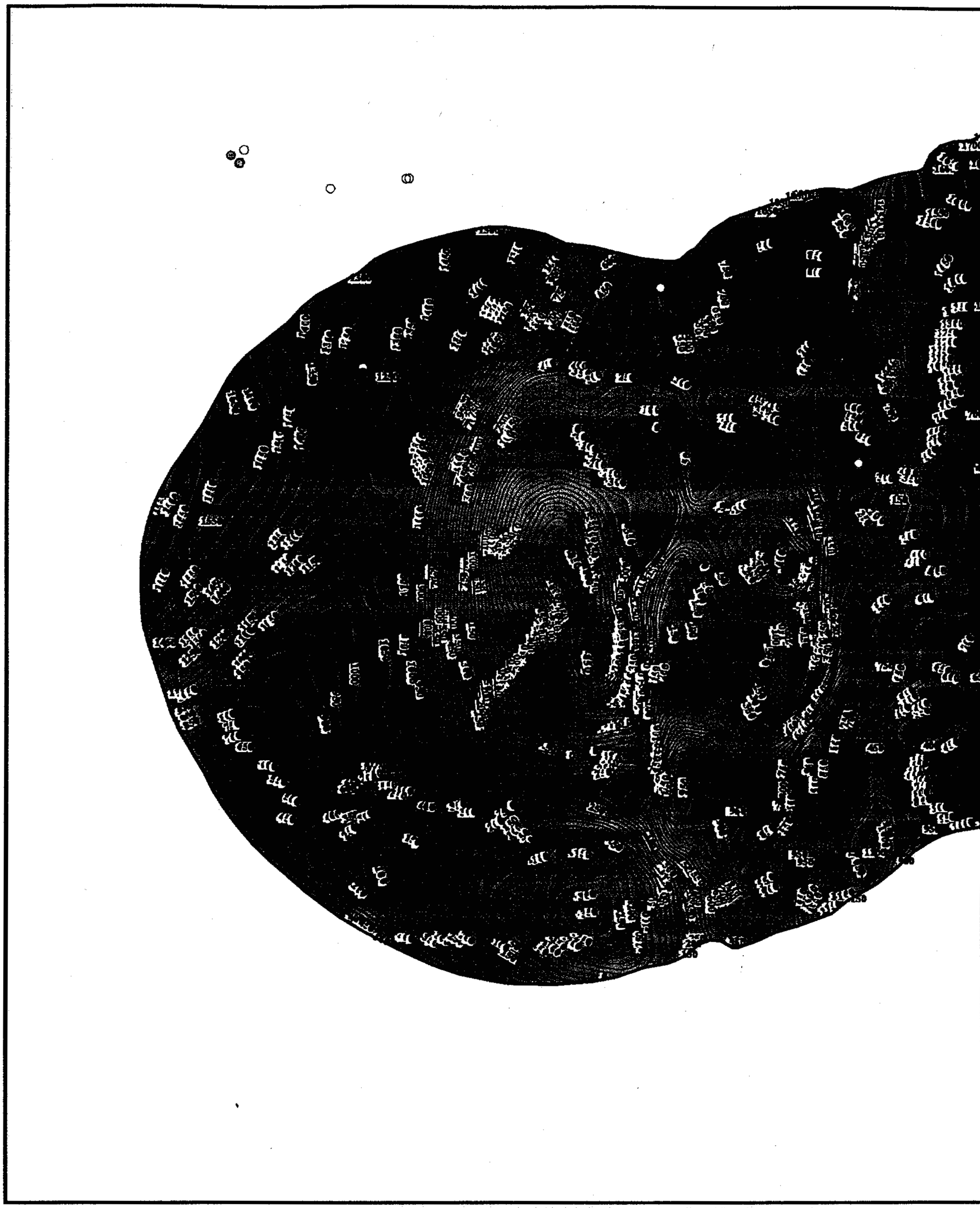

Figure A48. Model elevations for bottom of Bullfrog Tuff (Tcb) within region defined in Figure 1. Structural features can be identified by comparison with Figure A1. Unit is absent outside contoured region. Small circles show location of control points; filling colors define differences between observations and model as described for Figure A2. Boundaries of the Area 20 caldera, superimposed Basin-Range structures, and structural blocks are well defined. Cumulative offsets for pre-Tcb units are 850 m across the West Greeley fault, 1100 m across the West Boxcar fault, and 2100 m down eastward across the Purse and West Purse faults. South of the caldera, pre-Tcb units are 1100 m higher than within the caldera, and to the north they are 1300 m higher.